EUROPEAN ORGANISATION FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL

OPERATIONAL CONCEPT DOCUMENT (OCD)

EUROPEAN AIR TRAFFIC CONTROL HARMONISATION AND INTEGRATION PROGRAMME

DOCUMENT IDENTIFICATION SHEET				
DOCUMENT DESCRIPTION				
Document Title				
OPERATIONAL CONCEPT DOCUMENT				
EWP DELIVERABLE REFERENCE NUMBER				
PROGRAMME REFERENCE INDEX		**EDITION :**		1.1
FCO.ET1.ST07.DEL01		**EDITION DATE :**		4 January 1999

Abstract
This document contains a high level description of the target concept to support a uniform gate-to-gate ATM network for Europe which will meet the forecast growth in air transport demand into the early part of the next Century, and the airspace users' expectations for more flexible and cost-effective Air Traffic Management (ATM) services.

Keywords		
OPERATIONAL	CONCEPT	

CONTACT PERSON :	José Varela	**TEL :** 3401	**Division :** DED1

DOCUMENT STATUS AND TYPE					
STATUS		**CATEGORY**		**CLASSIFICATION**	
Working Draft	☐	Executive Task	☑	General Public	
Draft	☐	Specialist Task	☐	EATCHIP	☑
Proposed Issue	☐	Lower Layer Task	☐	Restricted	☐
Released Issue	☑				

ELECTRONIC BACKUP		
INTERNAL REFERENCE NAME:	Operational Concept Document (OCD)	
HOST SYSTEM	**MEDIA**	**SOFTWARE(S)**
Microsoft Windows	Type : Hard Disk	Word 6.0 for Windows
		CorelDraw 5.0 Visio 32

DOCUMENT CHANGE RECORD

The following table records the complete history of successive editions of the present document.

ISSUE	DATE	REASON FOR CHANGE	SECTION PAGES AFFECTED
0.A	01.10.96	Initial working draft for ECTF review and comment.	All
0.B	15.11.96	Second working draft for ECR and ECTF review and comment.	All
0.C	10.01.97	Third working draft for FCOT review and comment.	All
1.0	01.03.97	First circulation of Proposed Issue.	All
1.A	05.06.98	Circulation of first Work-up to Edition 1.1	All
1.1	04.01.99	Circulation of Released Edition 1.1	All

FOREWORD TO EDITION 1.1

The Operational Concept Document (OCD) provides a high-level description of a Target operational concept for Europe[1] for the early part of the next Century based on the main operational and functional options available to realise the overall objective set out in the ATM Strategy for 2000+. It is one of a set of related foundation documents[2] which set out the main drivers, scope, mission, objectives and strategic path towards a gate-to-gate orientated Air Traffic Management (ATM) network that will meet the needs of the aviation community in Europe until 2015.

The Target operational concept was developed initially by the European Air Traffic Management System Concept Task Force (ECTF), which comprised members drawn from a wide spectrum of the aviation community, including both civil and military airspace users, National administrations and Air Traffic Service providers, professional bodies, the European Commission and Industry, assisted by EUROCONTROL staff. It was subsequently reviewed and strengthened by other expert groups and teams, and has also been the subject of an extensive consultation process within the wider European aviation community. As such, the concept represents the general consensus of the various aviation partners on how ATM operations in Europe could be conducted in the year 2015.

It should be stressed that the OCD concerns itself with the **operational** aspects of the future ATM network in 2015. Statements concerning technical issues are confined to identifying generic technologies that could support the concept, and their likely availability. Likewise, the Institutional issues which affect the concept's realisation fall outside the scope of the OCD. Further discussion on these issues, together with a description of, and the rationale for, the proposed path of change to reach the target concept, is contained in the ATM Strategy for 2000+ document. Together, the OCD and the ATM Strategy for 2000+ provide a cohesive view of future ATM in Europe out to 2015.

Interim concept operations for the intermediate stages between now and 2015 are being developed and will be included at a later date.

The time-frame of the concept inevitably means that there are uncertainties surrounding some of the longer-term events leading to its realisation, and not all of the issues involved can be resolved at present. These uncertainties will be explored as a part of Research and Development and validation activities. The management framework for the activities that are needed to progress towards the target operational concept are set out in the ATM Strategy for 2000+. The concept will need to be re-visited at intervals to confirm its continuing validity as more precise information becomes available, and to reflect any changes to the ATM Strategy for 2000+.

Edition 1.1 has been reviewed by the Concept and Systems Development Team and aligned with the ATM Strategy for 2000+ document that is now being prepared for submission to the ECAC Transport Ministers. The OCD is being circulated to all EATCHIP Teams to provide feedback on the experience gained in EATCHIP/EATMP work and guidance for the continuation of the more detailed future activities.

---

[1] <Europe> is used to denote the area covered by the ECAC and EUROCONTROL member States, but excludes the airspace of Iceland and Oceanic airspace.
[2] Other related documents are: Mission, Objectives and Strategy Document (MOSD); Context and Scope Document (CSD); User Requirements Document (URD); and the ATM 2000+ Strategy Document.

PAGE LEFT INTENTIONALLY BLANK

EXECUTIVE SUMMARY

This document contains a high-level description of the proposed target operational concept for Europe for 2015 based on the main operational and functional options available to realise the overall objective set out in the ATM Strategy for 2000+:

´For all phases of flight, to enable the safe, economic, expeditious and orderly flow of traffic through the provision of ATM services which are adaptable and scaleable to the requirements of all users and areas of European airspace. The services shall accommodate demand, be globally inter-operable, operate to uniform principles, be environmentally sustainable and satisfy national security requirements.´

The concept describes the types and scope of ATM services needed to meet both the forecast increase in air transport movements, and the airspace users'[3] expectations for more flexible and cost-effective ATM services. The document sets out the main options that are available and highlights the differences between these options in terms of likely benefits and trade-offs. However, because of the uncertainties inherent in forecasting some longer-term events, not all of the issues surrounding the target concept are, or can be, fully explored or resolved at this stage.

Traffic forecasts indicate that air traffic in the ECAC region will more than double by 2015. Some parts of the airspace in Europe are already congested, and cannot absorb even today's levels of demand at busy times. Airspace users also want a more cost-effective and flexible ATM network which is responsive to their business needs. This generates the requirement for integrated ATM services which encompass gate-to-gate operations and considers ATM as part of a complex network involving the aircraft operators and airports to ensure that the best use is made of all available resources. It is also necessary to improve the levels of safety to reflect the increase in aircraft movements. **The main drivers for change in the ECAC region airspace are the need to simultaneously create additional capacity in the congested airspace areas while reducing direct and indirect ATM-related costs, and to increase safety levels.**

Current ATM concepts and national infrastructures have inherent limitations and will become progressively less than adequate as traffic levels rise. Airport congestion, in particular, is likely to become a major concern and constraint on future aviation growth.

It is possible to identify some strong trends in the way that air transport and ATM might develop based on agreed policies and strategies. Nevertheless, there are uncertainties surrounding the feasibility of some potential concept options and a number of possible choices as to which change path to follow, each of which has its own balance in terms of costs, and the capacity and flight efficiency gains which could be achieved.

The main concept options range between a 'managed' ATM environment based on traffic structuring, greater traffic predictability, longer planning horizons and extensive automated support, to a 'free flight' environment based on free routings and autonomous aircraft separation. In practice, the target concept will have to contain elements of most of the available options to meet the varying requirements of all of the airspace users and the differing types of regional traffic conditions. **However, the overriding need is to generate extra capacity in the busiest traffic areas while increasing safety levels.**

The ATM Strategy for 2000+ provides management framework for making collaborative decisions as to which options are feasible and cost-effective according to the circumstances being addressed.

The target concept is predicated on layered planning, based around a strategically-derived 'daily airspace plan', with collaborative decision making between the involved parties and with an evolving change to managing resources rather than demand. ATM is considered as a network which includes airports and ECAC region airspace, including that in TMAs and around airports, as a continuum for airspace planning and flight management purposes in order to optimise the available resources. Airspace divisions are based on ATM needs rather than on national boundaries, but without compromising sovereignty. The concept incorporates a mix of route structuring, free routings and autonomous aircraft operations to answer the needs of a diverse user community. The concept involves fundamental changes to current roles both in the air and on the ground; a distribution of responsibilities for separation assurance between the air and

---

[3] <Airspace users> is used to denote ALL users of airspace including State, military, airline, other commercial and business, recreational, etc..

ground ATM elements according to aircraft capabilities and the services provided; greater use of computer support tools to cope with increased levels of service and to keep ATC and cockpit workload within acceptable levels; and a more dynamic and flexible management of airspace.

TABLE OF CONTENTS

ANNEX A GATE-TO-GATE SCENARIOS AND VIEWPOINTS

1.0 INTRODUCTION TO THE SCENARIOS

APPENDIX 1 COMMERCIAL IFR FLIGHT IN FREE ROUTING AND FREE-FLIGHT

APPENDIX 2 COMMERCIAL IFR FLIGHT IN MANAGED AIRSPACE

APPENDIX 3 GENERAL AVIATION'S VIEWPOINT

APPENDIX 4 MILITARY AVIATION'S VIEWPOINT

LEFT INTENTIONALLY BLANK

List of Acronyms

2-D-3-D-4-D		Two-Three-Four Dimensional
A-SMGCS		Surface Movement Guidance and Control System
ACAS		Airborne Collision Avoidance System
ACCS		Air Command and Control Systems
AIS		Aeronautical Information Services
AMS		Arrival Management Systems
AOC		Airline Operations Centre
ASAS		Airborne Separation Assurance Systems
ATC		Air Traffic Control
ATFM		Air Traffic Flow Management
ATM		Air Traffic Management
ATN		Aeronautical Telecommunications Network
ATS		Air Traffic Services
B-RNAV		Basic Area Navigation
CDM		Collaborative Decision-Making
CDTI		Cockpit Display of Traffic Information
CFMU		Central Flow Management Unit
CNS		Communications, Navigation and Surveillance
CSD		Context and Scope Document
DMS		Departure Management Systems
DOP		Daily Operations Plan
EATCHIP		European ATC Harmonisation and Integration Programme
EATMP		European Air Traffic Management Programme
ECAC		European Civil Aviation Conference
EFR		Electronic Flight Rules
F&CM		Flow and Capacity Management
FANS		Future Air Navigation Systems (ICAO Special Committee)
FFAS		Free Flight Airspace
FFM		Free Flight Mode
FM		Flow Manager
FMS		Flight Management System
FTS		Fast-Time Simulation System
FUA		Flexible Use of Airspace
GA		General Aviation
GAT		General Air Traffic
GNSS		Global Navigation Satellite System
HMI		Human Machine Interface
ICAO		International Civil Aviation Organisation
IFPS		Integrated Initial Flight Plan Processing System
IFR		Instrument Flight Rules
IM		Information Management
MAS		Managed Airspace
Mode S		Selective Co-operative Secondary Surveillance System
MOSD		Mission, Objectives and Strategy Document
MSP		Multi-Sector Planner
MTCDR		Medium-Term Conflict Detection and Resolution
OAT		Operational Air Traffic
OCD		Operational Concept Document
R&D		Research and Development
R/T		Radio telephony
RAP		Recognised Air Picture
RNAV		Area Navigation
RNP		Required Navigational Performance
RVSM		Reduced Vertical Separation Minima

SA		Separation Assurance
SAR		Search and Rescue
SMS		Surface Management Systems
SUA		Special Use Airspace
SVS		Synthetic Vision System
SWIM		System-Wide Information Management
TCAS		Traffic Alert and Collision Avoidance System
TMA		Terminal Manoeuvring Area
TSA		Temporary Segregated Airspace
UMAS		Unmanaged Airspace
URD		User Requirements Document
VFR		Visual Flight Rules
VMC		Visual Meteorological Conditions
WGS-84		World Geodetic System-84

1.0   Background and Purpose

1.1   Background

The European Air Traffic Control Harmonisation and Integration Programme (EATCHIP), and the Central Flow Management Unit (CFMU), were introduced to combat the Air Traffic Control (ATC) delays experienced in the 1980s because the ATM network and airports[4] did not have the capacity needed to cope with the rapid increase in demand.

The early EATCHIP phases were aimed at harmonising and integrating the current ATM network. This brought some capacity gains and helped to reduce or stabilise delays despite a substantial increase in traffic in recent years. However, traffic forecasts indicate that the demand for air transport will continue to grow significantly into the next century, and there are limitations to the capacity improvements that can be achieved using present the present concepts and ATM infrastructure. The current ATM network and concepts would successively be unable to cope with traffic increases of the magnitude predicted. Added to this, greater competition in the air transport market is also increasing the pressure on ATM service providers to provide more flexible and cost-effective services. Hence there is a need for a new ATM concept for Europe which incorporates recognition that ATM is part of a complex network involving both airports and the aircraft operators, and that European airspace has to be viewed as a continuum for ATM purposes and optimised at a pan-European level.

In 1992 work started on the formulation of an ATM concept for Europe covering a 2005-2015 time-frame, taking full account of the International Civil Aviation Organisation (ICAO) CNS/ATM global developments, encapsulating the principles of continuous gate-to-gate flight management, and within a harmonised implementation and transition strategy. This was followed by the development of an ATM Strategy for the years 2000+, setting out the processes and measures by which the forecast demand in Europe could be met. Together, the Operational Concept Document and the ATM Strategy for 2000+ provide a comprehensive view of how ATM in Europe should develop into the early part of the 21st Century.

1.2   Evolution Through Time

A primary consideration of ATM is safety, and the introduction of changes to any ATM network has to be rigorously controlled. Changes to ATM necessarily involve long lead times, not only to ensure that they are feasible and thoroughly tested before operational implementation, but also to take account of the investment already made in existing systems and people, and of the large and diverse international aircraft population involved. In consequence, the future ATM network has to build on the foundation of existing and already-agreed activities, and follow a stepped evolutionary path where each change builds on the previous one and provides a platform for the next.

The effects of the early benefits stemming from the continuation of current and planned EATCHIP activities will still be felt in the post-2000 period. The more significant system changes which form part of the European Air Traffic Management Programme (EATMP), which will replace EATCHIP, will be introduced progressively from around 2000 onwards. These will be geared to deliver step by step benefits in line with the actual traffic demand. While it is accepted that both aviation and ATM will continue to evolve in the future, the target concept is based on a practical planning horizon of 2015. The OCD nevertheless provides an adaptable framework which can be used to help define future concept changes beyond that date.

1.3   Concept Definition

While it is possible to identify some of the more stable aspects of the future concept based on already agreed policies and strategies, the feasibility and potential benefits of other possible components of the concept have yet to be fully tested. Choices and trade-offs concerning the different options relating to system performance, costs, capabilities, and the resolution of various constraints and requirements will have to be made. The main choices are not necessarily about which options should be kept and which should be rejected, but more about the circumstances in which the various options would provide benefits as part of a consistent concept of operations,

---

[4] The term airport as used in this document refers to both airports and aerodromes, as defined by ICAO.

including the necessary transition phases.

Concept development work is therefore, aimed at analysing various needs and possibilities and at providing a description of the ATM target concept.

What the concept definition process seeks to help deliver is:

- a structured framework of future ATM concept possibilities;

- a clear view of the next generation of change within the context of the longer term evolutionary view to avoid dead ends;

- clear traceability through to the system facilitators needed to support the concept;

- identification of the key research and development (R&D) issues that will help to validate concepts and close down the range of options.

The target concept, therefore, should not be seen as a fixed 'blueprint', but as a framework for progressing change over time.

1.4   Document Purpose

The purpose of the OCD is to provide readers with a high-level description of the Target concept for Europe for the year 2015.

It forms part of a sequence of related foundation documents, comprising, and published in the order: Mission, Objectives and Strategy Document (MOSD), Context and Scope Document (CSD), and User Requirements Document (URD). It has in turn, and together with those documents, been used to help in formulating proposals for a comprehensive, gate-to-gate oriented, ATM Strategy for Europe for the years 2000+ (ATM 2000+ Strategy Document).

Proposed Issue 1.0 of the OCD was widely circulated within the aviation community as part of an extensive consultation process, was further reviewed by the Concept and Systems Development Team and aligned with the ATM Strategy for 2000+ document that is now being prepared for submission to the ECAC Transport Ministers. The OCD is being circulated, as Released Version 1.1, to all EATCHIP Teams to provide feedback on the experience gained in EATCHIP/EATMP work and guidance for the continuation of the more detailed future activities.

1.5   Document Scope

The document is largely concerned with General Air Traffic (GAT) operations, but addresses Operational Air Traffic (OAT) issues regarding access to airspace by State aircraft and systems interoperability.

1.6   Document Structure

The document structure is:

Chapter 2 - The Need for Change - identifies briefly why a new European ATM concept is needed;

Chapter 3 - Main Components of the ATM Concept - examines what the future ATM network operational concept should include and the key concept drivers which shape and influence concept choices;

Chapter 4 - Trends and Options - details identifiable concept trends based on currently agreed policies and strategies and examines the main concept options;

Chapter 5 - Choices and Trade-Offs - identifies the impact that the various options have on the key concept drivers, the airspace users[5], and the ATM service providers;

Chapter 6 - The Target Concept - provides operational statements describing the target concept together with an outline of how the concept will work;

---

[5] The term <airspace users> is used throughout the document to denote all users of airspace, including State, military, airline, other commercial, business and recreational users etc..

Annex A - Gate-to-Gate Scenarios and Viewpoints - provides more detailed illustrations on how the concept can be expected to apply to, or be seen from the viewpoint of, a number of airspace users and service providers.

1.7   Further Work

Further work is needed to clarify the path to the future target concept from today's ATM network, particularly for many of the longer-term events involved. Likewise, the uncertainties about some of the concept components have to be resolved through R&D and validation work, and proposed changes will be subjected to cost-benefit analysis. The management parameters for this work are set out in the ATM Strategy for 2000+ , and details of the results obtained will be contained in a range of both complementary, and lower-level, documents dealing with the programmes and activities associated with the various concept components (e.g.: collaborative airspace management and organisation; flow management; communications; navigation; surveillance; transition and implementation plans; etc.). Both aviation and ATM will also continue to evolve in the period leading to the realisation of the target concept, which will, in turn, become a foundation for further future change. Changes to the agreed path to the future associated with all of these factors will be reflected in the ATM Strategy for 2000+.

The OCD and concept description will need to be re-visited and refined at regular intervals to reflect changes agreed to the ATM Strategy for 2000+, and as further information about concept options become available.

2.0 The Need for Change

2.1 Continuing Traffic Growth

The underlying requirement for change stems from the need to handle forecast traffic increases in excess of 100% by 2015 safely and cost-effectively, while providing airspace users with the ability to operate on time and with greater flight efficiency.
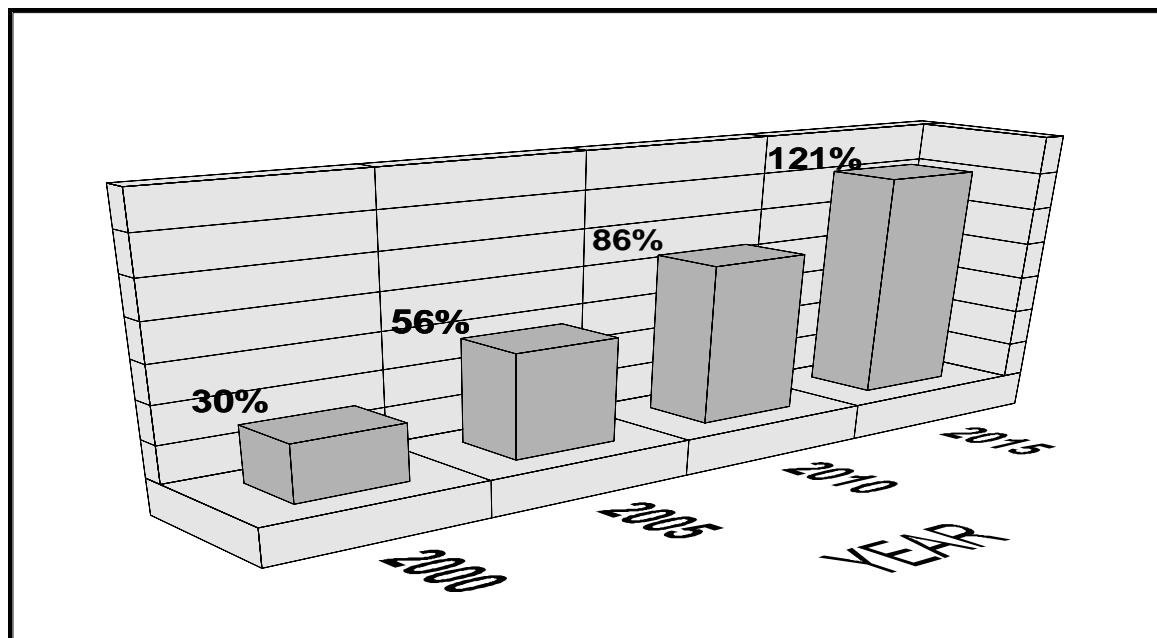
Forecast Traffic Increase

* Overall annual "Base Case" traffic forecasts for the entire ECAC region based on 1995 traffic figures.

Present traffic densities vary across the ECAC region airspace, with the main points of en-route congestion situated largely in the core area[6], particularly around the larger cities and industrial areas. This airspace is expected to see a continuing growth with the emphasis on peak hour, short-haul flights involving the hub airports and main city pairs links. Areas outside this core area will also see marked increases in air transport movements as demand increases over time, and traffic densities approaching those currently experienced in the core area.

2.2 ECAC Region Airspace

Future traffic growth will occur in an airspace area which is unique in a number of ways. Parts of the ECAC region airspace are amongst the busiest in the world and contain high concentrations of climbing and descending traffic. The majority of flights take place entirely within the ECAC region boundaries, have an average flight time of about seventy-five minutes, and involve rapid turn-rounds at their destination airports. The airspace itself has a complicated structure, aligned principally on national boundaries and with classes of airspace in which different states apply different rules. Added to this, the prevailing weather patterns in Europe often restrict available airport capacity, particularly in winter when poor visibility conditions can frequently develop.

2.3 User Requirements

In addition to providing additional capacity, the future ATM network will also have to meet the user community's expectations for a more cost-efficient and flexible ATM network capable of responding dynamically to their operational and business needs.

In particular[7], the users have emphasised that the future ATM network should:

---

[6] The ECAC core area is defined in the EATMS Context and Scope Document (CSD).

[7] A full list of user requirements is given in Volume II of the EATMS User Requirements Document

- accommodate a wide variety of capabilities and provide differing levels of service according to the users' needs;

- provide flight management service gate-to-gate in which flights will be managed continuously within the ATM network throughout all phases of flight.

- be predicated on a process which is based on user-requested flexible and dynamic trajectories;

- keep the aircraft operator as the final decision makers in the planning and conduct of the flight;

- ensure the co-existence of both GAT and OAT[8] operations.

The users do, nevertheless, recognise that there have to be some trade-offs to find an economically sensible balance between the need to increase capacity, to provide greater flight efficiency and, at the same time, to improve levels of safety.

2.4 Airspace Users

The future ATM network will provide services to, and interact with, a number of airspace users, all of whom have a right of access to European airspace. The principal airspace users are:

Commercial Airlines: These will be the majority users of ATM Services. To airlines, the ability to operate to published schedules punctually and efficiently is the most significant concern after safety. These schedules involve a myriad of connecting and interdependent flights and events, in which the resources (aircraft and flight-crew) used for a particular flight, or flights, form part of a continuous inter-connected process in which delay can have a serious and growing effect on subsequent flights. Different airlines however, have different priorities depending on their business objectives, and seek to satisfy these and optimise their operations by determining the optimum departure and arrival times of their aircraft and the routes and levels at which they wish them to fly.

General Aviation (GA): GA aircraft, will also continue to be a significant user of ATM Services. As for commercial traffic, their numbers can be expected to increase in the future. The objectives of GA Business (or Corporate) aviation are, in general, similar to those of commercial airlines. They also need to be able to react at short notice to the demands of customers and, for many, the ability to operate at maximum efficiency is critical because of their relatively small and potentially vulnerable profit margins. Aerial Work aviation needs to reserve airspace for its particular type of operations. In addition, there are considerable numbers of powered and non-powered aircraft operating principally under VFR (recreation and sports aviation) that have a legitimate right of access to European airspace, but which may not be able to fit a multitude of different equipment to their aircraft.

Military: Military airspace requirements stem from aviation, ground and sea-based activities. Military aviation, on which part of this document focuses, operates a wide range of aircraft types, from large transport aircraft, through high-level and low-level ground attack, fighters and training aircraft, to helicopters and unmanned aerial vehicles. These aircraft are required to operate in all airspace environments and have special airspace requirements in addition to general airspace use (e.g. low-level flying, in-flight refuelling and air-to-air combat training). The operation of some military aircraft, such as transport aircraft can, in general, be considered as similar to that of a commercial airline operator, but other aircraft, particularly fighters and training aircraft, often have limited physical space available in the aircraft for equipment that would enable them to conform fully to civil airspace access requirements.

---

[8] With regard to military airspace users, the target operational concept must meet the objectives set out in the Mission, Objectives and Strategy Document (MOSD) concerning the freedom of action necessary to perform military tasks.

2.5   ATM Service Providers

A multiplicity of different groups of people and organisations contribute to the provision of the ATM services needed to make an ATM concept work. These groups and organisations range from small to large private companies, through specific-purpose associations, quasi-government and government organisations to multi-national and pan-European organisations (Meteorological Services, Performance Appraisal and Environmental Concern Groups). Some aspects of their involvement with ATM are covered here in summary.

Meteorological Services

High quality meteorological information in the calculation of flight trajectories, both at pre-flight and during flight, is a pre-requisite for a safe and efficient future ATM network. Meteorological data will, as now, be derived from a number of forecast services, but will also come as real-time data from ground-stations and from aircraft. The integration of this data between the Meteorological community, the airspace users and ATM will be derived via System-Wide Information Management (SWIM), enabling a significant increase in the flow of data between them. This real-time information, allied to the combination of better meteorological models, continued growth of computing power, and the availability of additional, more accurate and more up-to-date data, will enable the delivery of improved aviation weather products that can be used on the ground or in the aircraft. This will help to improve forecasting accuracy, real-time knowledge of meteorological conditions and more optimised decision-making by all parties.

Aeronautical Information Services (AIS)

The capability of AIS to collect and disseminate information relating to the structure and composition of the ATM physical environment will be considerably enhanced by the use of IM. The flow of information necessary for the safety, regularity and efficiency of international air navigation will be provided by a harmonised, co-ordinated service delivering quality-assured information to all interested parties, both in the context of the gate-to-gate concept and in support of CNS.

Performance Appraisal

The operation of the future European ATM network will be based on measurable safety and performance objectives and targets tailored to reflect regional and local requirements. These will provide the framework for the successful realisation, maintenance and continued development of a safe, efficient and uniform ATM network. The bodies associated with setting and monitoring these objectives and targets and the scope of their responsibilities are described in the ECAC ATM Institutional Strategy.

2.6   Environmental Considerations

As well as trying to meet the requirements of the airspace users, the future ATM network has a responsibility to those affected by the environmental impact of aviation, and environmental measures which protect against emission and noise pollution will be an important factor. The most effective contribution that the concept can make in helping to reduce the environmental effects of aviation operations, particularly at and around airports, is to reduce delay and congestion. However, as in other concept areas, a balance has to be found between the efficiency of ATM operations and their environmental effect.

Aircraft emissions - Studies show that carbon monoxide and hydrocarbon emissions are highest when aircraft are operating at low power settings (descent idle, taxiing, queuing). In addition, under high temperature and pressure conditions, nitrogen and oxygen react to form nitrogen oxides and carbon dioxide. (The pollutant effects of these gases are not yet fully verified but can be expected to be so by 2015.)

Aircraft noise - The use of automated support tools will help to optimise approach and departure patterns around airports. However, while this will help improve efficiency, it could also produce flight patterns which concentrate the noise nuisance from aircraft in particular areas. Support tools need therefore, to assist in providing a balance between: noise abatement requirements, the reduction of aircraft emissions, the increase of airport efficiency, the optimisation of controller workload and capacity enhancement.

The future ATM network may also contribute to reducing the impact of aviation on the

environment by:

- reducing the amount of time between start-up, take-off and landing, and shut-down;

- optimising aircraft routes, thereby reducing flight time;

- enabling aircraft, when possible, to fly at their most efficient engine performance levels thus minimising emission pollution.

2.7 Aircraft Profiles and Capabilities

The types of aircraft fleet mixes, operating characteristics and operating patterns (hub and spoke airfields) are not expected to change to any significant degree before 2015, but a more stringent economic environment will add pressure to minimise related costs. Likewise, while there may be improvements in aircraft operating characteristics, aircraft flight profiles and operating envelopes are expected to be broadly similar to those of today.

Conversely, aircraft avionics are expected to continue to evolve and become more sophisticated. There will also be extensive use of aircraft datalink communications to transfer information, both between aircraft in the air, and between the air and ground systems, and a growing reliance on more accurate satellite navigation, which is in turn supporting a move towards defining aircraft trajectories in 4-D. The further development Aircraft Flight Management Systems (FMS)s will lead towards more integration with air-ground ATM. At the same time however, aircraft will become increasingly capable of operating more independently of the ground ATM network than in the past.

These factors underline the need for the capabilities of the aircraft and ground systems to remain in step. However, the more sophisticated avionics fits might not be universally adopted because of their high cost, and **the future ATM network will have to accommodate a broad mix of aircraft capabilities**.

2.8 Airport Capacity

Many of the major European airports already suffer from traffic congestion and are sources of flight delay. This problem will be exacerbated and affect more and more airports unless airport capacity is increased, and remains, in step with improvements to en-route capacity. The provision of extra airports and runways, together with improvements in passenger handling and the terminal and access facilities that are needed to meet the increase in passenger demand, are part of national, institutional and political decision making processes. Although these matters are outside of the scope of ATM, it must be recognised that they will have a significant impact on it.

Nevertheless, airports must be considered as part of the overall ATM network within a gate-to-gate approach, and ATM concepts, processes and procedures must ensure that the potential air-side airport capacity available at any particular point in time is used to the optimum effect. Even so, by 2015 a number of European airports in the high traffic density areas will be routinely operating at their maximum capacity levels for prolonged periods of the day, and will be unable to increase their throughput because of air-side infrastructure or environmental constraints.

An objective of the target concept therefore, is to help alleviate airport capacity constraints as far as is possible by ensuring that ATM network optimises the use of the available air-side airport infrastructure (i.e. gates, aprons, taxiways and runways), particularly in poor visibility conditions. It therefore contains measures and mechanisms to improve the management and use of the airspace at and around airports, and the airport air-side facilities and infrastructure, under all weather conditions.

2.9 Gate-to-Gate and Integrated Planning.

At present, there is little integration or collaboration between the ATM network, the airport operators and the airspace users' planning processes. The overall objective of the gate-to-gate strategy[9] for the future concept is to develop an integrated concept which will provide a smooth and seamless process from flight preparation through flight execution to charging for the services provided. The sharing of common base information between the parties is fundamental to its success.

---

[9] A gate-to-gate strategy which builds on previous APATSI work is currently being developed as part of on-going EATCHIP work activities.

The intention is to improve the interface between ATM, the airports and aircraft operators to ensure the most efficient use of local airport resources and **not** to attempt to rigidly pre-plan flights from gate-to-gate. Nevertheless, it has to be recognised that the gate-to-gate strategy may not be fully developed during the early time-frame, and the benefits which it offers will arise incrementally over time.

2.10 The Need for New Concepts

The current ATM network and supporting concepts are already fully stretched in some ECAC region areas and cannot absorb present traffic levels without the need to restrict demand during peak periods to ensure safe operations. The efficiency of ATM will be improved to some degree by a better and more efficient use of the present resources. Existing and planned EATCHIP measures, like the Central Flow Management Unit (CFMU), Integrated Initial Flight Plan Processing System (IFPS), the Flexible Use of Airspace (FUA) concept[10], the Free-Routing airspace concept[11], Reduced Vertical Separation Minima (RVSM), optimised route structures, and improved controller support tools will help to provide some capacity and safety gains. However, these measures alone will not provide the extra capacity needed to meet the forecast demand into the next century, particularly in the already congested airspace areas. **In consequence, the capacity problems would continue to get worse as the traffic levels increased if no further improvements were made.**

> **The inherent inability of the present ATM concepts and infrastructure to absorb the forecast growth in demand, to meet the users' expectations in terms of improved flexibility, punctuality and reduced costs, or to fully exploit current and emerging technologies, drives the need for new concepts for the ECAC region airspace.**

The risk of loss of safe separation increases as traffic levels rise, and at a proportionally faster rate. Increases in traffic levels therefore, have to be matched by increases in safety if unacceptable delays are to be avoided, and this requires the use of enhanced computer tools and procedures that many of the present legacy systems are unable to support.

It is possible to introduce more advanced technical systems without employing new concepts. However, technical systems cannot resolve capacity issues by themselves and have to be accompanied by operational changes before benefits can be realised. Also, they do not address the central problem facing ATM in Europe, that of finding extra capacity. Additionally, a fragmented, technically-driven approach would bring its own problems in terms of uniformity and the provision of seamless services.

The overall problem is that today's legacy ATM network and concepts evolved historically to meet national requirements. The technical systems, many of which were introduced over a decade ago, are not suited to the pan-European ATM network approach which is now essential to meet future demand, and the ATM concepts which they were designed to support are reliant on levels of human cognitive abilities which could not be sustained if the predicted demand is realised. They are also predicated on a national airspace divisions and airspace management structures which do not make the best use of the finite airspace resources available, or reflect the sophistication and capabilities of the equipment now fitted in many aircraft.

One of the most significant constraints is the limitation imposed by the current airspace sector operations and their associated ATC workload. Traditionally, capacity increases have been achieved by dividing airspace into smaller and smaller airspace sectors to off-set the workload that they bring. This method, however, follows a law of diminishing returns because of the additional co-ordination work it generates. There is also evidence that any future gains made this way would progressively reduce, and be insufficient to meet the forecast growth in demand. This is particularly true for the already congested traffic areas where any further division of airspace would be difficult, or even, in some ECAC region areas[12], impossible.

> **One of the fundamental issues which the concept has to address is to find ways to**

---

[10] The FUA concept addresses dynamic airspace sharing and co-ordination procedures between civil and military authorities. Plans exist to extend the FUA principles to encompass all civil airspace authorities.

[11] The Free Route airspace concept addresses the use of free routings in the upper airspace.

[12] The mean transit time for aircraft in some ECAC airspace sectors is already less than 5 minutes.

> **improve the operational productivity of the overall ATM network in order to generate additional capacity and improve safety levels, while at the same time improving services and keeping ATC and cockpit workload within acceptable and safe limits.**

The expectation of the users for more efficient flight profiles, leading to time and fuel savings and reduced operating costs, also calls for changes in the way that ATM is currently provided. Aircraft systems have usually outstripped the capabilities of the ATM ground system to exploit them. This has prevented aircraft operators from realising the full benefits of their investment in terms of more flexible and cost-effective operations. There is also a lack of integration of planning between the airspace operators, airports and ATM. This inhibits the ability of both the users and ATM to react effectively to real-time changes in circumstances as they occur.

> **There is a need to introduce more integrated and collaborative ATM concepts which can fully exploit aircraft capabilities and provide the scope to offer airspace users greater flexibility.**

2.11 The Key Drivers for Change

The **key drivers for change** that the concept has to help resolve are:

> **To provide additional capacity to meet the increased demand in the congested traffic areas, and at airports, in terms of ATM-related operations, while reducing direct and indirect costs.**

> **To simultaneously improve safety levels.**

These key drivers are the prime considerations because of the:

- current constraints on capacity in the high traffic-density areas in ECAC region airspace;

- increasing severity of these constraints (without the introduction of new concepts);

- ripple effects that this would have on the whole ECAC air transport network;

- additional pressures of airline de-regulation and greater competition.

They are, however, not the only issues that have to be taken into account in the development of the future ATM network. Capacity increases will also need to lead actual traffic demand, and the future ATM network has to find a balance between the long time periods associated with change, and the unnecessary costs associated with providing too much excess capacity too soon.

2.12 Capacity and Flight Efficiency

In simple terms, the overall capacity of the current ATM network is determined by three inter-related factors,[13] all of which have to be in balance if delays are to be avoided:

- Airspace - the number of aircraft that the airspace can physically accommodate;
- ATM - the number of aircraft which the ground ATM network is capable of handling safely;
- Airports - the numbers of aircraft which can take-off and land during the hours of operation.

The physical capacity of the airspace is a function of how much airspace is available, the amount and capabilities of the traffic that wishes to use it, and the rules and separation minima applied. ATM capacity is dictated by the ATC system capabilities and by the workload limits of the roles and tasks of the people who provide the ATM services, in particular in present concepts, the tactical controller. The present division and use of airspace does not make the most efficient use of airspace resources, both en-route and at and around airports, at a pan-European level and

---

[13] ICAO specifies 5 capacity factors - En-route, Airport, Airspace, ATM and ATM Network. This has been reduced to 3 factors to simplify the issues discussed.

more dynamic management and use of airspace needs to be achieved. In terms of airport capacity, the relevant issue is for the future ATM network to exploit the available airport air-side facilities to the full and to make optimum use of the airspace at and around airports; and in particular, to improve the traffic throughput in poor visibility operations.

There is a complex relationship between capacity and flight efficiency and the trade-off between the two. For any given capacity, the degree of flexibility that an ATM network can provide diminishes as the number of aircraft using the system increases.

A system capable of supporting unrestricted demand, total flexibility and consistent punctuality would involve substantial and prohibitive costs, and is probably not possible because of the limitations imposed by the airspace and runway infrastructure available. Likewise, it would not be cost-effective to build an ATM network predicated on unusual or infrequent peaks in demand, and the future ATM network will not be able to eliminate all delays in all circumstances. Also, the costs of providing marginal capacity increases in saturated traffic areas needs to be examined carefully in relation to the level of benefits which could be gained. These issues form part of the trade-offs which need to made to find the best solution for particular airspace areas and the majority of airspace users.

3.0   Main Components of the ATM Concept

3.1   Components of an ATM Concept

In order to accommodate gate-to-gate operations in the future there is a need to develop new concepts for ATM; concepts that will encompass areas that have not normally been considered as being part of current ATC. By viewing operations from a new perspective, that of what ATM consists of, the constraints imposed by current technology or procedures and the core processes that are the essential components in making ATM work can be identified (Invariant Processes).

This perspective of **what** ATM consists of has the advantage of breaking the concept down into understandable segments which are entirely independent of any pre-determined concept themes or organisations (i.e. they are not concerned with **where** things are done, **who** performs them, or **how** they are carried out) and helps identify the main lines of action along which change has to be effected. However, the keystones are the roles and responsibilities, and ATM organisations employed in relation to decision making within each component or set of components.
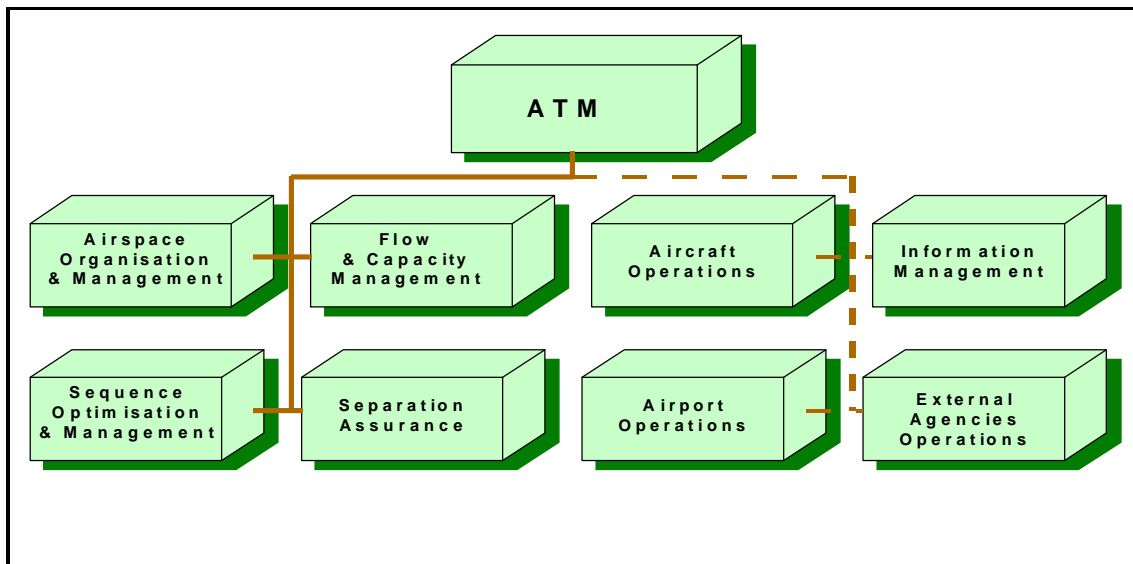
ATM Concept Components

Each of these concept components fulfils one or more specific ATM purposes, as follows:

Aircraft Operations - concerns the operations of the customers of ATM and is the central focus of the activities of all the other processes. As such, it is essential that the trends and potential future changes in aircraft operations are examined so as to assess the impact that they might have on the future ATM network.

Airspace Organisation & Management - Airspace organisation concerns the division of airspace into Regimes for the segregation of different types of air activity and the application of different rules of service and conduct. It also concerns all forms of airspace structuring, covering not only a promulgated route system, but also mandatory routings and flight level conventions. Airspace Management is the means of configuring the airspace and route system in the light of changing demand, for example, the segregation of active Military Training Areas.

Flow and Capacity Management - (F&CM) concerns ensuring the most efficient balance between capacity and demand. It covers actions both at the strategic level (many months ahead) when services are being planned, and at the tactical level in readiness for the day of operation. It acts on flow rates and traffic densities, rather than on individual flights. F&CM will be a major element of the future ATM network as traffic levels rise, the number of airports operating close to their capacity increases, and the 'firebreaks' in demand are squeezed out.

Sequence Optimisation and Management - concerns the arrangement and optimisation of the

order and spacing of traffic via metering, sequencing and synchronisation. It also include the provision and handling of queues, both in the air and on the ground if necessary. It operates on individual flights and is closely related to, and sometimes indistinguishable from, the separation assurance process.

Separation Assurance (SA) - concerns the means by which individual flights remain separated from others, in accordance with minimum separation standards, and from other hazards (e.g. terrain, obstacles, vehicles etc.). In many ways it is the foundation-stone of the ATM operation. A further element of SA is the operation of safety net processes that provide a layer of "last minute" protection to flights.

Airport Operations - concerns the traffic management and SA processes on or near the ground in which the different circumstances of application make them distinct from their airspace equivalents. It includes the interaction with stand allocation and other airport management functions.

Information Management - is a support process which is essential to all ATM concept components. It deals with the logistics of system-wide information management (SWIM) and sharing in a distributed environment of information suppliers and consumers. Conceptually, SWIM covers a broad spectrum of issues, including: continuously tracking the actors' information needs and their willingness and ability to share information; continuous management of the quality and interoperability qualities of the shared information in accordance with defined quality standards; continuous management of an adequate supply of updates to the shared information; management of the dissemination process customised to each information consumer's needs; management of information security; ensuring optimum usage of storage and communication resources; management of information ownership, cost, pricing and liability.

SWIM results in the timely distribution of validated, current and relevant information to the appropriate destinations of all of the actors who have the authority to access it. This can range from information needed in the strategic planning phases, through that needed by controllers on the day of operation, to the final archiving of data so that it can, in turn, be used for future strategic planning. IM enables two of the key elements of ATM in the future - Information Sharing and Collaborative Decision-Making (CDM).

External Agencies Operations - concerns the provision or receipt of services to or from external agencies who interface with, but are not, or are only indirectly involved with, the actual provision of Air Traffic Services (ATS) but are included so as to be able to examine potential future changes to those interfaces so as to assess the impact that these might have on the future ATM network. In general terms these external interfaces can be divided into the following organisations or agencies; adjacent ATC areas, Meteorological, Military (ATC units and others), Search and Rescue (SAR), Emergency, Accident/Incident Investigation, Regulatory, Cartographic and Law.

4.0 Trends and Options

4.1 Endorsed Policies and Strategies

A number of operational policies and strategies have already been endorsed and adopted for the ECAC region as a part of the on-going EATCHIP activities and, together with some of the existing practices, will shape some aspects of the ATM of the future. These include:

- ICAO principles for retaining the human in the decision loop and for human-centred automation;

- introduction of the FUA concept;

- the formation of the CFMU;

- the introduction of IFPS;

- implementation of Area Navigation (RNAV) in the ECAC region;

- the use of Required Navigational Performance (RNP) and mandatory RNP5 capabilities;

- the introduction of RVSM;

- the enhancement of EATCHIP activities to include gate-to-gate principles.

System-related strategies and policies which will facilitate or condition operational changes include:

- the use of Global Navigation Satellite Systems (GNSS) as the basis for future navigation in the ECAC region where this is beneficial;

- the use of Airborne Collision Avoidance System (ACAS) and Selective Co-operative Secondary Surveillance System (Mode S) in the ECAC core area;

- the development and use of integrated communications networks.

4.2 Trends

Inevitable Operational Trends

The operational implications of the endorsed ECAC policies and strategies, coupled to the areas where there are clear possibilities for progress, feed a number of inevitable trends[14] - or directions of change. These include:

- better adherence to existing separation minima and the introduction of reduced separation minima where needed;

- more dynamic and flexible use of airspace;

- optimisation of route structures;

- the increasing use of free routes and user-preferred trajectories;

- more sophisticated F&CM, with a growing emphasis on capacity rather than demand management;

- more integrated planning between ATM, aircraft operators and airports;

- improved cockpit awareness of the surrounding traffic situation;

- greater use of computer support tools to reduce ATC and cockpit workload.

---

[14] The trends are inevitable in the sense that the driving forces for change are clear and there are no obvious reasons to resist them. They are generally associated with areas where progress has been, or is being, made and which still offer the potential for further development.

OPERATIONAL CONCEPT DOCUMENT (OCD)

Related ATM Trends

There are also other more general ATM related trends which will influence the concept to some extent. The more significant of these involve:

- a greater emphasis on the definition of performance goals and measurements combined with stringent analysis of operating costs and potential investment returns;

- common rules and procedures for the ground and air elements applied uniformly across the ECAC region, and for common training objectives for both controllers and pilots, particularly for new concepts and equipment;

- growing pressure from the major fleet operators who have invested in advanced avionics for ATM charges to be related to the levels of service actually provided;

- a move to a collaborative and integrated airspace planning and management service, involving both civil and military authorities and activities, for the whole ECAC region to ensure that airspace resources are utilised to best effect.

Technical Trends

A number of advances in the technical domains are already mature and will enable beneficial changes in ATM operations. Whilst the OCD describes an operational concept, it is worth noting technical trends, in particular because of the interaction between available technical performance and its deployment conditions, and the exact operational procedures that it can support. Many of the issues about options for change discussed later in this chapter are related to these problems.

There will be a continuing need for a ground-based ATM element and a Communications, Navigation and Surveillance (CNS) structure for the foreseeable future. In addition to the provision of separation, there is a need to provide information for and about flights for reasons such as national security. Additionally, States have a legal responsibility to provide a certain number of ATM services, including assistance to aircraft in emergency or suffering equipment failure. There is a requirement therefore, for certain CNS and ATM infrastructures regardless of the type of operational concept adopted.

The identification of operational requirements and benefits needs to precede decisions on technical developments. Nevertheless, concept development cannot take place in a vacuum, and the operational concept has to be under-pinned by a feasible and achievable technological framework. In view of the time needed to develop technical systems, it is reasonable to assume that the future ATM network infrastructure out to 2015/2020 will be founded on existing technology or known future developments and trends. The future trends include:

Communications - the use of datalink communications for the exchange of non time-critical messages and clearances between air-ground, air-air, and ground-ground elements, and the use of the Aeronautical Telecommunications Network (ATN) as the primary communications network;

Navigation - the development and use of global satellite systems for navigation services;

Surveillance - integrated surveillance networks to provide high quality global surveillance coverage and data for all phases of flight which will provide identical and continuous information to all users;

Data Processing - new open connective networks for flight data and information processing to replace current fragmented databases and systems and facilitate better automated support (a key factor in the development of the future ATM network);

Air/Ground Systems - more sophisticated FMS capable of optimum (4-D) trajectory planning and following, advanced computer Human Machine Interface (HMI), and the development of synergised systems (voice recognition, artificial intelligence, etc.) to reduce controller and cockpit workload.

4.3   Options for Change

The various trends set out identifiable directions of change. However, there are still many options for the future ATM network where there are choices and trade-offs to be made, where there are still uncertainties as to the feasibility of the potential change, or of the benefits that could be gained. These are discussed around their main themes below.

4.4   Airspace Organization and Management

Flexible use of Airspace - The introduction of the FUA concept is the first stage in a move to the optimisation and more flexible use of the ECAC region airspace resources. Planned extensions to the concept to include full ECAC-wide civil and military airspace co-ordination will pave the way to greater flexibility. The main issues to be resolved are how far the FUA concept should be extended in some airspace areas like the lower airspace, how far it is feasible to make the airspace management process more dynamic and collaborative, and how to accommodate the different needs of all of the various airspace users.

Free Airspace or Segregated Areas - The trend towards more flexible use of airspace retains the notion of airspace regimes and categories to segregate different types of airspace users. Options range from the use of airspace boundaries to keep different users apart, to the treatment of the ECAC region airspace as a continuum where separation is provided on a flight by flight basis. The advantage of the latter would be freedom of access to all airspace for all users; the disadvantages, that all users would require a designated equipment fit, and that the ATM network and procedures would have to be sufficiently extensive to cater for a highly non-uniform aircraft population.

Flexibility - There are also options involving:

- how far airspace flexibility can be exploited while still remaining manageable, how dynamic and adaptive airspace changes could be, and on what parameters they should be based (for instance, how flexible control sector boundaries could be used in conjunction with flexible airspace boundaries, and if it is possible to align boundaries with particular traffic flows or peaks in demand);

- the retention of fixed sectors but, using automated support tools to reduce workload, with the possibility of increasing their size;

- the introduction of dynamically-sized sectors, dependent on particular traffic flows and density;

- the replacement of sectorisation with control on a flight-by-flight basis.

Routes and Routings - Various measures are already in hand to optimise the existing fixed route structures in the ECAC region and to make greater use of RNAV capabilities. This feeds two options:

- the optimisation of **traffic structuring** in those areas where some route structures will still be needed to meet capacity targets;

- the employment of free-routes and **user-preferred trajectories**, enabling flights to operate outside a pre-defined route structure.

   Traffic Structuring - Structuring traffic, by arranging traffic flows and patterns using pre-defined routes, exists today as a means of enhancing airspace capacity and improving punctuality. While it is possible to improve airspace capacity by better airspace management and enhanced or reduced separation, the busiest traffic areas will still operate close to airspace capacity limits at times of peak demand. There will be a continuing need to manage traffic and employ routes and routings in the busiest traffic areas to enhance capacity by designing out conflictions and thereby reducing ATC workload.

   Free-Routes and User-Preferred Trajectories - The trend to the employment of free-routes and user-preferred trajectories is led by the introduction of RNAV capabilities and a desire to move away from the restrictions on flexibility and flight efficiency imposed on airspace users by route networks. Free-routes and user preferred trajectories will enhance flight efficiency

and will be an alternative to structuring traffic. The options are to:

- retain the control over flights by the ground organisation, while enabling the airspace users to choose their own trajectories (free-routing). Such operations can already be supported to some extent by existing infrastructure and avionics;

- delegate the responsibility for the control of flights to the flights themselves, giving users the freedom to choose their own trajectories (autonomous aircraft operations).

Concept Mix - Given that both concept options will be used in the ECAC region airspace, there will be a balance to be achieved between:

- how much traffic structuring will be needed as a means of providing extra capacity in the busiest traffic areas and in reducing ATC workload;

- what mixture of pre-defined routes and free routings will offer the most benefits, and in what airspace and at what times.
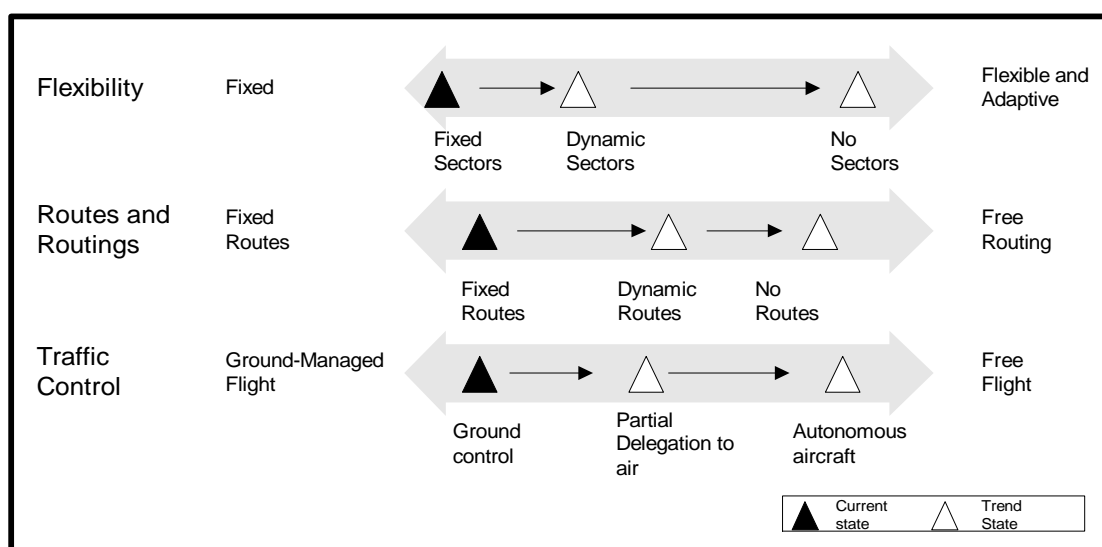
Airspace Organisation & Management Trends

4.5 Flow and Capacity Management (F&CM)

Flow management was introduced into the present ATM concepts as a protective measure using regulatory mechanisms to manage traffic. There will always need to be some means of comparing demand and capacity and managing any imbalance between the two, particularly with respect to airport capacity limits and changing meteorological conditions. There is however, a trend towards a more sophisticated, adaptive and dynamic process which can operate to finer capacity and time limits, with a progressive emphasis on the efficient and collaborative management of resources and capacities at airports and en-route so as to meet demand.

The options for F&CM are strongly influenced by option choices made in other areas. The principal option is for it to become a part of an integrated, layered planning process, supporting flights operating on predictive trajectories or in structured traffic flows, where the balance between capacity and demand is refined over time in co-operation with users and other service providers. The degree of integration to be applied between the various planning layers, between demand and capacity balancing, en-route ATM, and the airport slot allocation process, as well as the time horizons which should be used will depend largely on the choices that are made in other concept areas.

At present, the balance between airport demand and available capacity is addressed in the airport scheduling process, and airspace capacity is related to demand through flow management. There is a range of options as to how integrated and comprehensive the process for reconciling demand and capacity at the strategic planning stage could be.
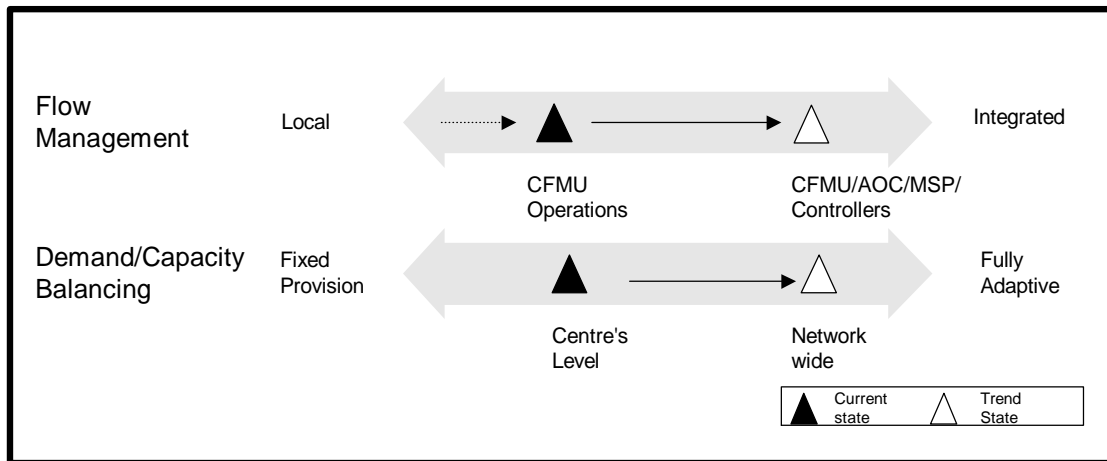
F&CM Trends

4.6   Sequence Optimisation and Management

A number of processes govern the expeditious flow of traffic for busy Terminal Manoeuvring Areas (TMA)s and airports, such as: flow slots, traffic smoothing, and metering and sequencing. There are many ways in which the granularity to which these processes operate could be refined, both in time and position, and in the degrees of integration which could be achieved. There are also choices in who arranges the traffic flows prior to landing, the time horizons adopted for applying this process, and the levels of integration to be used. The emphasis in the options for Sequence Optimisation and Management will vary between the busiest airports and others.

Busiest Airports - Because demand is expected to exceed the available capacity at many of the larger airports there are issues concerning how the processes that govern the expedition of traffic longitudinally (in time) might work, to what time parameters, who will apply them, and the need for, and extent of, holding either in the air or on the ground.

If en-route ATM is required to deliver traffic for these airports in a particular sequence at specific times, then it must have the ability to speed up or slow down aircraft. This will influence aircraft operating levels and, in consequence, flight efficiency. Conversely, the ordering and sequencing of traffic by airports raises questions as to the optimum level of integration which is feasible and the most beneficial - single airport, groups of airports, or across all of the ECAC region airspace - and the impact that this would have on the capacity and efficiency of the whole ECAC region network.

One of the most significant questions concerning the busiest airports therefore, is the possible need for a 'reservoir' of aircraft close to airports at the busiest traffic times, achieved by employing traffic holds or queues, as a means of providing a consistent flow of aircraft, thus optimising airport capacity and providing maximum throughput.

Other airports - Demand at these airports, although increased, will not exceed capacity and the key issue for them will be the optimisation of flight movements. The options centre around the degrees of flexibility in which the flights can operate and in exchange of data with flow management and en-route ATM so as to provide a user-efficient service, without the need for holds or for queuing or traffic smoothing.
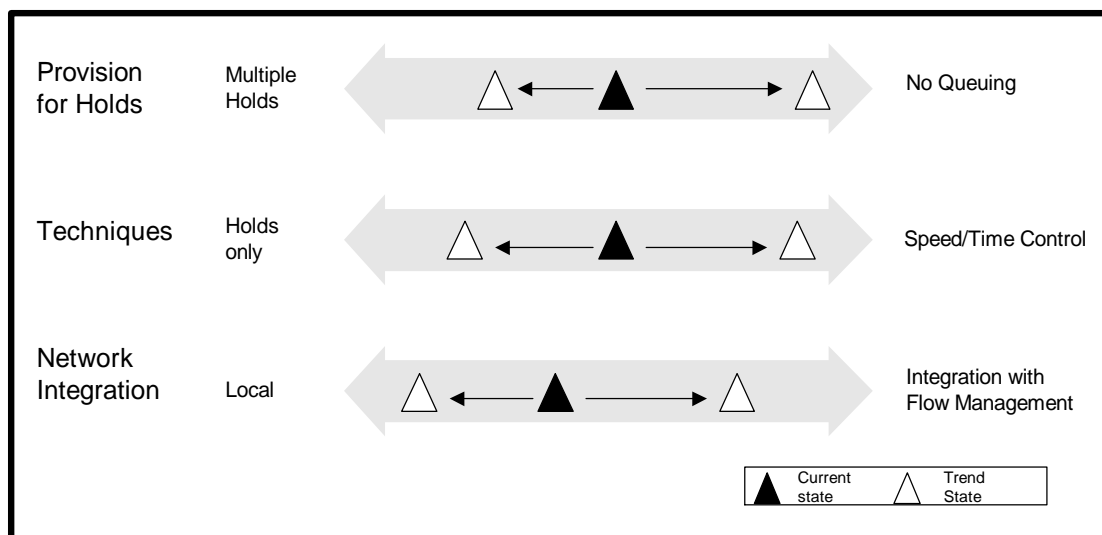
Sequence Optimisation and Management Trends

4.7 Separation Assurance

A fundamental principle of ATM is to apply positive separation between aircraft receiving the appropriate ATM services. The main safety layer remains that of preserving minimum separation distances between aircraft, rather than by using collision avoidance systems simply to miss other traffic. The way in which safe SA is applied, and the allocation of responsibilities to the humans involved, has a direct impact on workload, and is the central factor in shaping a concept and determining what it can deliver in terms of capacity and flight efficiency. Decisions made about SA also directly affect the choices that can be made in other concept component areas, particularly those concerned with **airspace organisation and management**, **F&CM** and **sequence optimisation and management**.

There is a broad set of options on how separation can be applied, who should be responsible, over what time horizons, and how much computer support can or should be used. The primary options fall between structuring traffic and retaining the current tactical controlling methods, but arranging it in orderly and predictable flows to retain the human cognitive process or designing structures where human intervention becomes an exception.

The main options are centred around a mix of:

Enhanced Tactical Operations **-** these are predicated on retaining the present ground-based tactical functions with shorter planning horizons. They incorporate an advanced tactical mode of operations based on traditional airspace sectors, but with extensive computer assistance to reduce ATC workload. This implies an extensive ground ATM element, but less predictability in terms of punctuality, and the need to find a balance between flight efficiency gains and potential delays.

Enhanced Planning Operations - these will also retain an extensive ground ATM infrastructure, but will use extended tactical planning horizons (in the region of 20 minutes) based around multi-sector planning operations that will extend flight clearances and cross-border operations, smooth traffic flows and smooth and reduce the levels of tactical intervention needed. How far ahead it is feasible and beneficial to plan has still to be determined. Enhanced planning is also dependent on the timely availability of high-quality predictive information, the introduction of multi-sector planning and operations to support the longer time horizons used, and significant changes to the present ground roles and responsibilities. The use of multi-sector planning raises a number of issues: on how far it should be allied to longer de-confliction horizons to reduce the incidence of tactical intervention needed, should it be considered as a means to generally smooth flows of traffic and workload over time to prevent the over-loading of control sectors and in either case, what should

be the rules to define the responsibilities for who has the authority to devise and implement decisions concerning flights across a number of control sectors.

Distributed Air and Ground Responsibilities - ACAS has already brought a new degree of situational awareness to the cockpit. This trend is likely to continue with the introduction of Airborne Separation Assurance Systems (ASAS), incorporating surveillance functions, longer look-head capabilities and improved cockpit HMI, so that flight-deck crews will become more aware of the surrounding airborne traffic situation. This has led to the concept of autonomous aircraft operations, where flight-deck awareness can be put to active and practical use.

Distributed air and ground responsibilities involves ground ATC sharing the responsibility for SA with aircraft suitably equipped to ensure their own separation from other aircraft, thereby reducing ground ATC workload and enhancing flight efficiency. The concept of autonomous operations is still in its early stages and although initial research shows some promising results[15], there are a number of issues need to be resolved, for example, the:

- feasibility and potential benefits of autonomous operations in busy traffic areas which are already well served by CNS/ATM infrastructures;

- the levels of functionality required in various traffic densities and the levels of benefits that could be obtained in relation to the costs involved;

- ability of autonomous aircraft to negotiate safe trajectories in multi-conflict situations;

- separation minima to be adopted which, due to the certification issues involved, may be in excess of or less than that which could be achieved using ground based systems;

- balance of how many aircraft would have to be suitably equipped before worthwhile benefits in terms of flight efficiency and costs in the ECAC region airspace could be realised.

Autonomous aircraft operations will need changes to aircraft avionics, to ground CNS and ATM infrastructures and to controller/flight-crew roles and responsibilities. There are distinct benefits for the users in areas where there is little or no ground CNS/ATM infrastructure and some users believe that it has benefits in other areas. As the future ATM network must fit within the global ICAO CNS/ATM structure, the pressure to cater for autonomous aircraft operations within ECAC region airspace will grow as its use spreads in other areas. The choice therefore, is not whether these operations should form part of the concept, but how the future ATM network can follow a migration path to encompass them.

Computer Support - The use of computer support is a key factor in off-setting the potential increases in workload that will be caused by the increased levels and complexity of air traffic in the future and will lead to changes in the roles and responsibilities of the ground control teams and between the ground and the air.

A central requirement is to have the "human in the loop", but the information that will be available in the future will be far more extensive, comprehensive and complex than now, and greater reliance will have to be placed in computer support tools to process the information and to provide potential resolutions to problems. The main options therefore, relate to the creation and validation of the best balance between:

- automating ATM functions whilst enabling the human to retain a mental image of the air picture[16];

- supporting the capacity increases required;

- delegating decision-making capability to the support tools in some circumstances, whilst retaining overall human control.

---

[15] For example, the FREER-1 study (Free Route Experimental Encounter Resolution (Autonomous airborne mode))
[16] See also section 6.9 'Air Traffic Services' with regard to possible changes in the extent of the mental 'air picture' and situational awareness that will need to be retained in the future.
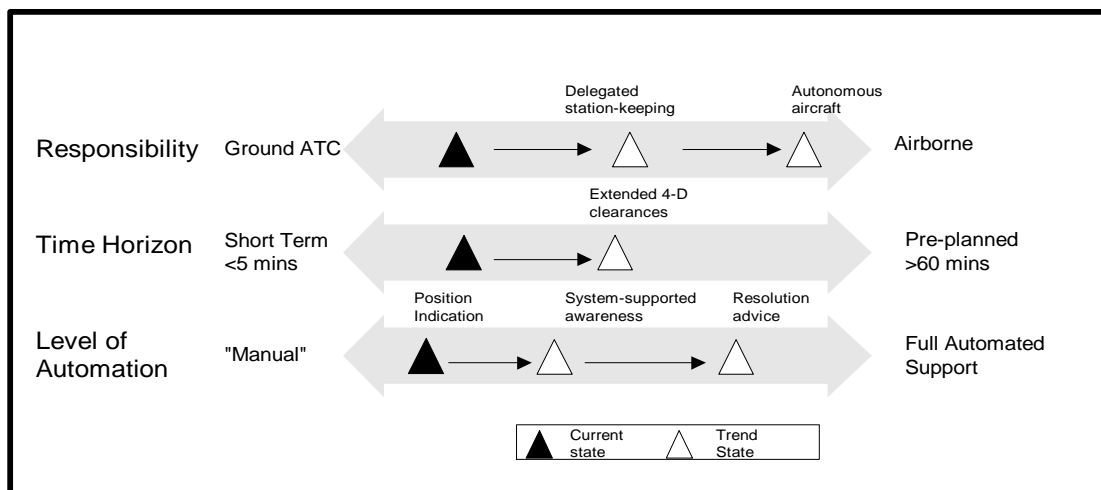
SA Trends

4.8 Airport Operations

The drivers in airport operations derive principally from the needs of the busiest airports to utilise all available capacity. The main goal for the ATM process therefore, is to maximise capacity, subject to the constraints of the existing physical airport limits, political and environmental constraints, and separation minima. The trends are; towards computer assistance to support arrival and departure sequence optimisation, towards integrated planning across the whole airport and to reduce the "capacity gap" between airport throughput in normal and low visibility conditions.

Issues are to determine how to balance the optimal sequence desired by the airport against those desired by Flow Management and by the users.

4.9 Aircraft and External Agencies Operations

The determination of concepts for these areas is beyond the remit of the ATM operational concept document. It is however, necessary to continue to be aware, where they impact on ATM, of the trends and developments in these areas. The principal trends are for a rapid increase in information technology, data gathering and exchange, together with other advances in technology and capabilities.

4.10 System-Wide Information Management

In step with advances made in the Information Technology industry, there is a distinct trend in the way airspace users, airports and ATM service providers conduct their business and manage operations, namely:

- using increasing amounts of (digitised) information faster and in more automated and integrated/networked ways, in order to achieve the mission and to optimise the use of scarce resources (e.g. aircraft, crew, fuel, airspace, runways, ATM capacity, environmental constraints etc.) to the maximum extent possible;

- where possible, decisions will be taken collaboratively rather than in isolation;

- information will become a commodity, and it will need to be shared on a system-wide basis.

The trend towards an information-rich collaborative decision-making environment where data is exchanged system-wide will change the focus from the individual problems of *interface standardisation* and *information exchange* to the need for **overall co-ordination and management of the logistics of information sharing** in a distributed environment of information suppliers and consumers.

ATM is coming under pressure to adopt system-wide concepts and practices aimed at the removal of today's technical, organisational and institutional barriers that prevent easy and timely use of relevant information.

5.0   Choices and Trade-Offs

5.1   Option Choices

The options set out in the previous chapter represent possible ways to the future ATM network. Each option has different capabilities and characteristics in terms of the benefits it may offer and the cost and risk that it might incur. The options all interact with each other to a greater or lesser degree, but in some cases, they may be mutually exclusive (for example: an area which will rely solely on free-routing and autonomous aircraft operations will have no need for the infrastructure needed to support Structured Route airspace operations). The choices as to what options are finally selected will depend on institutional, national, customer, financial and technological issues.

The diagram below gives a simple representation of the approximate relative benefits in flight efficiency and flexibility (for airspace users) of the three main options for aircraft operations (Structured Routes, free-routing and autonomous aircraft operations). At this stage the precise balance of benefit, cost and risk, and the relative merits of one option against another are unknown, although there are many opinions, based either on initial research or intuition. The possible range of benefit, cost and risk are therefore, shown as circles of possibility which, at this stage of our knowledge, are relatively large and overlap considerably. As a general rule, it is seen that the greater the benefits to user freedom provided by the more advanced technical solutions, the greater are the cost and risk to the users and service providers. The results of research over the coming years however, can be expected to clarify and quantify the benefits and the costs and risks involved so that informed decisions on what options to choose can be made.
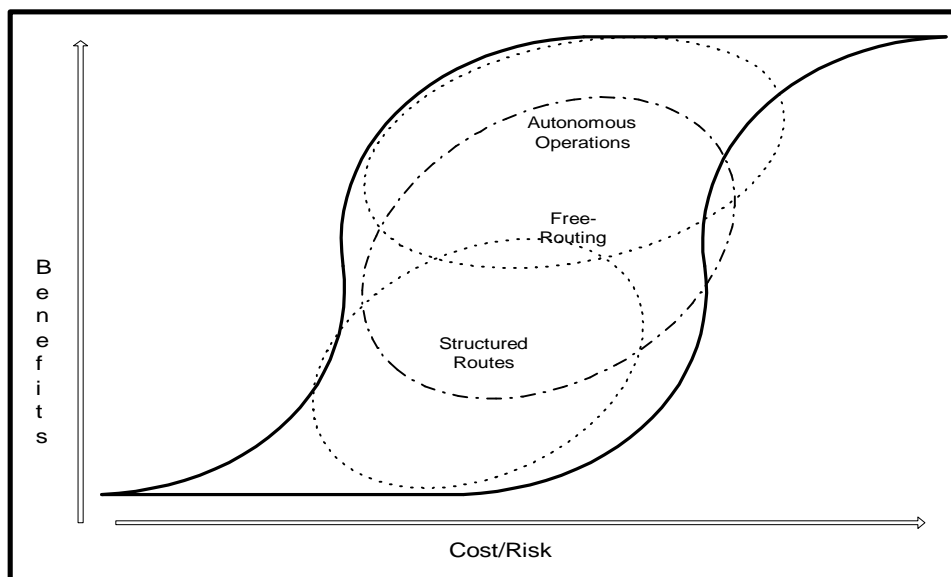
Aircraft Operations Options

5.2   Trade-Offs

Each of the main concept options will have an impact on the trade-off between potential capacity gains, on flight efficiency and on the complexity of the user and service provider systems needed to support them. However, no one concept option can provide a total answer and there is no single 'perfect' ECAC-wide solution.

Different areas of ECAC region airspace will have different priorities, dependent on the characteristics of their traffic demand and the capabilities of their system(s). Any future system can be expected to require most, if not all, of the options outlined previously, but with emphasis on

particular aspects in order to resolve an area's specific problems. A major concern for a significant proportion of the airspace will be to find the extra capacity needed to meet the future demand in the busiest areas. In other areas the emphasis will be on providing flight efficiency and flexibility, and both will need to satisfy increasing safety level requirements.

Capacity-driven options for the busiest areas of ECAC region airspace and the busiest airports, based on ground control for SA, show emphasis in the need for Structured Routes, for focusing on metering and sequence optimisation, the provision of 'reservoirs' of aircraft to 'feed' the ATM network and operate airports at maximum efficiency and on enhanced tactical planning so as to improve en-route and airport operations. The trade-offs will be between the provision of flight schedule predictability and punctuality against reductions in flight efficiency and flexibility.

Free-routing options, still based on ground control for SA, show emphasis in the need for enhanced planning tools, enhanced tactical tools and on the use of distributed responsibilities. The trade-offs will be between the provision of flight efficiency and flexibility against an increased cost of aircraft equipage and perhaps, some reduction in capacity.

Autonomous aircraft operations options, based on airborne SA, show emphasis in the need for enhanced planning tools for the ground, on data communications and on ASAS. The trade-offs will be between the provision of the highest levels of flight efficiency and flexibility against increased cost of aircraft equipage and in the revision of roles and responsibilities and the balance of shared responsibility between the human and the automated tools.

6.0   The Target Concept

6.1   A Path for Change

The following sections set out the proposed target concept which is intended to meet the needs of the user community in the light of the traffic growth expected in the next century.

The target concept should be viewed as the goal towards which the future ATM network is aiming, and which involves evolutionary change to provide incremental benefits in line with the growth in demand. It should not be seen as an ultimate system. The concept will need to evolve to reflect changes in the air transport environment. In this context, it encompasses the principle of moving to the 'ideal' while recognising the limitations of the 'real'.

6.2   A Mixture of Concepts

In practice, some aspects of all of the main concept options described in the previous chapters will have be incorporated in the target concept to cater for the differing traffic scenarios likely to be encountered in the ECAC airspace. The real choices are more about the circumstances in which the options can best be exploited, rather than whether or not to introduce them. Changes will also be influenced by the degree of additional productivity that the various options will actually deliver and, in some instances, this will not become clear until they have been fully investigated through R&D and validation activities.

Concept Focus

The primary need is for the concept to generate the additional capacity required to meet the forecast traffic growth in the busy traffic areas while improving safety levels, and this will condition the flexibility and flight efficiency which can be offered during peak traffic periods. In future, the airspace will be regarded a common resource for ATM purposes in which the air traffic will evolve, unconstrained by National boundaries. There will be a continuing need to manage traffic and employ traffic structuring in the congested traffic areas over the ECAC airspace to provide the extra levels of capacity needed during periods of high demand. This structuring will involve a mixture of more direct routings between the busier cities and industrial areas, and fixed 2-D and 3-D routes to manage the sequencing of traffic around airports and cater for less capable aircraft. The balance between fixed routes and more direct routings will progressively alter as the capabilities of ground and air systems improve over time.

These changes will be accompanied by the exploitation, in specific airspace, of ASAS to transfer SA responsibilities from the ground to the air for suitably equipped aircraft, as avionics fits improve and enhanced computer support and control tools are introduced to off-set ground and air workload. Enhanced computer support will be a key factor in containing the workload of the humans within acceptable bounds, particularly for tasks such as conflict-free trajectory planning.

Greater freedom of movement and improved flight efficiency can be provided by increasing flexibility, where capacity and workload do not present problems, and can be extended to the busier traffic areas when demand allows. It will be confined initially to portions of the upper airspace, where the traffic patterns are not too complex and the capabilities of the present air and ground systems will be sufficient to meet the initial demand.

The evolution in the stages of increased flexibility will depend mainly on the timings of the advances of the necessary supporting systems, the rate of upgrade of aircraft fleets, and the perceived costs and benefits.

This progression, while probably generating some benefits along the way, will eventually transform the ATM scene into one where the best possible use is made of capabilities available in both the air and ground elements. However, it will be essential to identify the balance between the benefits of the investments made in the ground systems versus the investments required in the aircraft. Additionally, the limits of the cost/density threshold that will permit the operation of autonomous aircraft capable of free flight have still to be considered.

Airspace boundaries will continue to be used to segregate different types of airspace users, although these will become more dynamic as FUA is extended to include all air transport operations across the entire ECAC region. Classification of airspace will be based on ICAO classifications, although these may need to alter over time to reflect changes in airspace use and aircraft capabilities.

ATM, aircraft operations and airport planning functions will become more integrated, and planning more comprehensive, facilitating an evolutionary transition from demand to capacity balancing as information on flights becomes more accurate and timely, and the inter-operability of systems improves. Strategic planning will provide a better match between demand and available capacity. This, in turn, will provide the foundation for daily airspace plans which will be refined over time as more details become available. The main role of ATC will be to implement a daily airspace plan as necessary to reflect the actual situation. More advanced FDPS will support better predictive tools and longer tactical horizons leading to the introduction of multi-sector planning with less emphasis on the need for ATC intervention.

The rate at which concept changes occur will depend on a number of factors but will be driven largely by the benefits which can be gained.

6.3   Main Objectives and Focus

The OCD sets out the practical operational target for realising the principles and objectives contained in the ATM Strategy for 2000+ whose Mission is:

> **For all phases of flight, to enable the safe, economic, expeditious and orderly flow of traffic through the provision of ATM services which are adaptable and scaleable to the requirements of all users and areas of European airspace. The services shall accommodate demand, be globally inter-operable, operate to uniform principles, be environmentally sustainable and satisfy national security requirements.**

Stemming from this Mission Statement, the ATM Strategy for 2000+ sets out the following main objectives areas:

> **SAFETY, ECONOMICS, CAPACITY, ENVIRONMENT, NATIONAL SECURITY and DEFENCE REQUIREMENTS, UNIFORMITY, QUALITY, HUMAN INVOLVEMENT and COMMITMENT.**

The Strategy objectives, together with equity of treatment and flexibility of operations, encapsulate most of the various users' requirements for the future ATM network.

At a more specific level, the safety objective conforms to the ECAC Safety Policy, and can be broadly characterised as 'improving safety levels[17] in the face of increasing traffic demand'.

The capacity objective broadly encapsulates the ability to modulate capacity to accommodate variations in demand, and to deploy additional capacity at short notice to handle special demand. It assumes that it is the responsibility of ATM to provide the necessary en-route and terminal airspace capacity, and to exploit scarce airport air-side resources to the full.

The target operational concept embodies a new approach to the way that ATM services are provided in order to obtain network-wide benefits. The principal concept characteristics and their main advantages are:

Flight Management from Gate-to-Gate - flights will be managed continuously within the ATM network throughout all phases of flight. This will improve planning and reactions to real-time events and make better use of resources, including those at airports.

---

[17] Accidents, incidents and risks associated with ATM operations, as distinct from airworthiness, etc. Exactly how this should be translated into practical objectives and actions will be the subject of subsequent work.

Enhanced Flexibility[18] and Efficiency - the trajectory of a flight will be managed to reflect the best balance that can be achieved at any moment between the aircraft operators' needs and the prevailing flight or ATM circumstances. This will enhance the efficiency of both individual flights and total fleet utilisation, while improving the management of traffic.

Collaborative Decision-Making - decisions will be made by those best positioned to take them, based on the sharing of validated real-time information. This will provide the means for greater efficiencies on a network-wide and individual flight basis. Improved information management will provide a foundation for a dialogue between the various parties in real-time during all phases of flight.

Responsive Capacity Management to Meet Demand - a combination of flexible ATC sectors and capacity management will be applied to ensure that demand can be handled safely and efficiently with minimum delay. This will provide operational and cost efficiencies by allocating resources to satisfy variations in traffic.

Collaborative Airspace Management - a collaborative airspace planning and management mechanism based on the flexible use of airspace, and involving both civil and military authorities will be established. This will ensure that airspace is managed and used as a continuum in a flexible and dynamic way across the whole ECAC region.

Extended Levels of Automation and Communication Support - future operational improvements will require the support of more sophisticated computer assistance tools and human-machine interfaces able to exploit air/ground data communication, higher quality trajectory prediction data, and the exchange of data between ground units. This will increase ATC productivity and enhance safety nets.

In practical terms, the concept focuses on providing ATM capacity above the present capabilities in the busier traffic areas, while improving safety levels, through a variety of measures including traffic structuring, and providing the users with the opportunity for greater flight freedom of movement in the other areas.

Freedom of movement encapsulates the ability to operate aircraft as economically as possible in accordance with the users' business needs. However, there will have to be trade-offs between capacity and flight efficiency to meet the forecast demand in some areas. The principle are that these trade-offs should be explicit, and that the future ATM network must have the in-built flexibility to optimise freedom of movement according to the prevailing circumstances and traffic demand.

6.4 The Target Concept Statement

The future ATM network will comprise the following elements: Flight Operations, Airspace Management, Air Traffic Flow Management (ATFM) and ATS. These elements will evolve and take on different roles to those performed today as they become more integrated.

---

[18] Flexibility, in the context of the target concept is (subject to aircraft and ground capabilities and periods or zones of applicability):

- **access to airspace** - freedom for airspace users to enter airspace which is not normally available on a permanent basis, or to operate to and from airfields which are not the normal base or destination, at times that suit their needs;

- **variations to departure time** - freedom for users to vary their departure times according to their needs;

- **free routing** - freedom for users to plan a flight using any user-preferred routing between two points;

- **accommodating differing user capabilities** (equipment, aircraft performance etc.) - the ability of ATM to match the service provided to the capabilities of the user by exploiting the capabilities of aircraft with advanced avionics, while also continuing to accommodate aircraft with less capable avionics fits;

- **changing flight intentions** - freedom for users to request or select a change of trajectory (route, routing, vertical profile, speed) in flight;

- **free flight** - freedom for users to exercise the responsibility of separation from other traffic and to effect trajectory changes in any direction.

TARGET CONCEPT STATEMENT

A collaborative and layered planning system, strategically co-ordinated and operating gate-to-gate, incorporating capacity management, and based on three airspace regimes with shared responsibilities for separation assurance involving changes to roles and responsibilities under-pinned by enhanced computer support:

Collaborative and Layered Planning System

The exchange of current, relevant data between ATM, airports, AOCs and aircraft, to enable the different system layers to support flexible decisions where needed, taking advantage of the availability of a common information pool, enhanced equipment, computer tools and operating procedures designed to increase capacity, efficiency and safety.

Strategically Co-ordinated

Co-ordinated strategic planning involving ATM, airports and airspace users to balance and match capacity and demand.

Operating Gate-To-Gate

Starting at the moment in a flight when the user first interacts with ATM and ending with the switch-off the engines. It also includes the process of charging users for ATM services.

Capacity Management

Evolving to managing capacity rather than demand based on :
- service quality agreements;
- layered sets of planning functions.

Three Airspace Regimes

Unmanaged Airspace (UMAS)
- unknown traffic environment;
- rules of the air.

Managed Airspace (MAS)
- known traffic environment;
- 3-D routes and routings;
- responsibility for separation with the ground.

Free Flight Airspace (FFAS)
- known traffic environment;
- free routings and autonomous operations;
  - .

Roles and Responsibilities

Human ultimately responsible for tactical separation:
- revised individual and team roles (ground and air);
- enhanced planning on a multi-sector basis;
- extensive computer support and tools.

Separation Assurance

Allied to the airspace regime and vested in the air or on the ground - but explicit.

Note: The following define terms that are used in the target concept but which do not appear in current ICAO definitions:

- **autonomous separation capability** - the ability of an aircraft to satisfy functional and performance requirements of CNS that will allow it to assume responsibility for its own separation from other traffic;

- **free flight mode (FFM)** - operations comprising both free-routing and autonomous separation;

- **airspace regime** - a defined method of governing a specified volume of airspace (the term encompasses both the types of airspace and the method of separation applied within them).

In general, the target concept will be supported by the incremental development and evolution of:

- integrated data management and advanced computer based tools;

- real-time and system-wide information sharing;

- accurate and enhanced CNS and aircraft management systems' capabilities;

- air-ground and air-air data communications;

- ground-ground data communications;

- collaborative airspace management and F&CM techniques.

Declared airport capacities will provide the foundation for defining the traffic that can be accommodated and for ensuring the consistency of flight operations gate-to-gate.

6.5 Collaborative Decision-Making (CDM) and Information Management

One major factor that will contribute to delivery of the required capacity will be a collaborative layered system in which the main actors will maintain a permanent close collaboration, using a pool of available updated information, to support their level of decisions at any time. The main elements are the implementation of a CDM process, supported by an efficient and effective process of IM.

Collaborative Decision-Making - Although a process, CDM is essentially a concept that anticipates the need for active collaboration of all the actors involved in order to reduce potential risks as much as possible. The goal of CDM is to enable the corresponding actors to improve mutual knowledge of the forecast/current situations, of each others constraints, preferences and capabilities, so as to pro-actively resolve potential problems, in which the person best able to make the decision is the one who does so.

System-Wide Information Management - The decisions taken by controllers, pilots, dispatchers, flight planners, weather forecasters etc. represent information that is used by others as inputs to their own planning and decision making processes. In order for the ATM network to function properly, all of this information (decisions and inputs to decision-making) must be available when and where required. This entails more than just establishing a suitable CNS infrastructure or making systems interoperable. Without advanced IM at the overall system level, the present lack of ATM integration will be perpetuated.

> The aim of SWIM is to combine the forces of all suppliers of ATM information so as to assemble the best possible **integrated** picture of the past, present and (planned) future state of the ATM situation, as a basis for improved decision making by all ATM stakeholders during their strategic, pre-tactical and tactical planning processes, including real-time operations and post-flight activities.
>
> Successfully managing the quality, integrity and accessibility of the complex, growing web of distributed, fast-changing, shared ATM information, is the main operational enabler for the target concept. SWIM, in turn, depends on a number of technical enablers, one of them being an adequate CNS infrastructure.

Introduction of **System-Wide Information Management** principles and mechanisms will provide the capabilities that will ensure the common, up-to-date shared view of all relevant ATM information (**the ATM pool**) is maintained in a distributed stakeholder environment, in accordance with defined scope, quality and integrity requirements.

This will ensure that the information needs of ATM stakeholders - both within and outside the ATM network - will be satisfied in a much more flexible, cost effective manner than today.

System-Wide Information Management principles and mechanisms will need to deal with the following subjects:

- information ownership, licensing and pricing;

- information security management;

- ATM pool content management;

- information acquisition process;

- information dissemination process.

6.6 Gate-to-Gate

From the view point of ATM, Gate-to-Gate is considered as a process initiated at a strategic planning phase, progressing during the following planning and implementation phases, and terminating with the processes of charging for the services provided. Currently this process is developed in such a way that the dialogue or collaboration among the actors involved can be effective between the same group of actors (e.g. Tower, Approach and En-Route ATC), can be weak (e.g. ATC/Airports) or can be very weak or non-existent (e.g. Airlines/ATC or ATFM/Airports).

The aim of the gate-to-gate process is to optimise the flight of aircraft (optimising includes safety, economical, environmental, technical etc.). The different phases for the preparation, realisation and conclusion of a flight are currently the result of a series of disconnected actions and decisions taken at different levels by different actors, with different. The results can be seen as a discontinuous series of actions and decisions that prevent the successful achievement of the goals of the flight.

To reduce the uncertainties for flights and in order to generate the benefits required, the target concept is developed on the understanding that gate-to-gate is a CDM process, involving several actors (e.g. Airspace Users, Airports, ATFM etc.) contributing to successful planning, realisation and post-flight activities of a flight supported by IM.

6.7 Airspace Management

Airspace management and planning will become a more integrated and collaborative function, supporting all aspects of planning, design, maintenance, update, civil/military co-ordination, regulation and airspace legislation. The main objective will be to optimise the airspace structure of the entire ECAC airspace for the benefit of all users at both the strategic planning and tactical levels.

As part of Airspace Management, the development of the airspace structure will consider the ATM requirements for CNS performance, and the corresponding impact of available CNS techniques, systems, and infrastructures.

ECAC airspace will be considered as a continuum for ATM purposes, organised in accordance with the need for the provision of ATM services, not constrained by National boundaries and based on the principles of contiguous volumes of airspace, under the responsibility of units providing ATM services, in particular ATC services. **This does not imply changes to sovereignty, or preclude the application of special conditions to ensure the national security and defence requirements of individual States.**

Airspace Regimes

ECAC airspace will consist of 3 different types of airspace regimes - Managed Airspace (MAS), Free Flight Airspace (FFAS) and Unmanaged Airspace (UMAS). The definition of these regimes encompasses all the current ICAO airspace classification, legislation and applicable rules (including Visual Flight Rules (VFR) and Instrument Flight Rules (IFR)). However, it may be necessary to consider different ways of organising the airspace to be more responsive to the airspace users needs, and to adapt current ICAO rules and legislation. A particular factor is the need to ensure that the future classifications and rules adopted are common to all States, and that they are applied uniformly across the entire ECAC region.

The vertical, lateral and time boundaries of the airspace regimes organisation will be determined during the airspace planning phases taking into consideration the forecast air traffic flows and the corresponding aircraft capabilities. It will be possible to dynamically readjust the boundaries between MAS, FFAS, and UMAS in accordance with the needs of En-route operations. ATM will have the responsibility to make the information on the extent of MAS and FFAS available to all potential airspace users during the planning phases and on the day of operation. Particular attention will be paid to safety-related information.
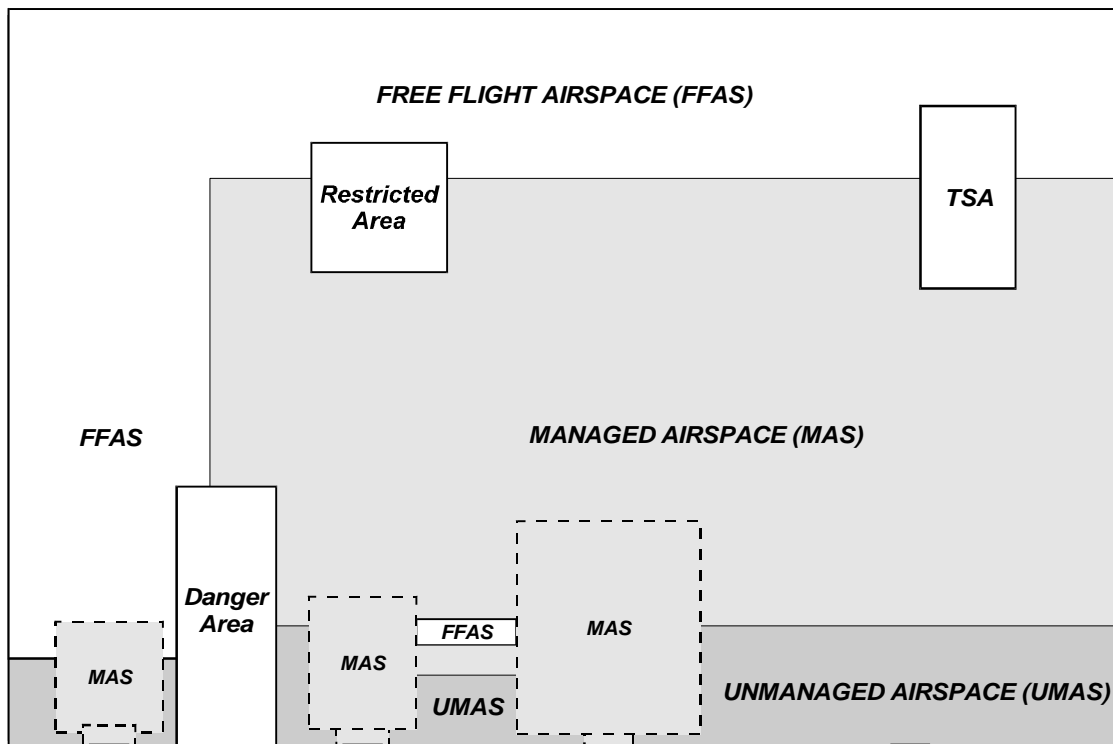
Plan View of Airspace

Note: The descriptions of airspace given below relate largely to GAT. Access to MAS and FFAS by OAT is outlined in section 6.13 'Military Aspects'

Unmanaged Airspace (UMAS)

UMAS will be basically the same as today's "Outside Controlled Airspace" and subject to similar rules as those applied now (Rules of the Air), but there will be harmonisation of airspace categories and uniformity of rules across the ECAC region, with easier access to more accurate information, including the ability of equipped aircraft to negotiate and agree separation action. The availability of low-cost and simple to use SA systems, could be of particular benefit in this airspace regime.

There will be no interaction with ATM for aircraft operating in UMAS, except for those flights that wish to notify their presence either by filing a flight plan (in the air or on the ground) or by broadcasting their position (and perhaps intentions) by electronic means. ATS, in particular, Flight

Information Services, may be provided to aircraft in UMAS on request.

Managed Airspace

MAS in 2015 will consists of airspace (defined by vertical, lateral and time boundaries) that will be needed to support en-route operations within which the control of aircraft is the responsibility of the ground ATM organisation. Traffic structuring, in the form of 2-D and 3-D route networks (Structured Routes), will be used in the busiest areas at peak times to enhance capacity, to organise traffic flows and to reduce the incidence of conflictions for En-route and TMA operations. In other areas and outside peak times in the busiest areas, MAS will support the operation of aircraft using user-preferred trajectories outside the structured routes (the Free-Routing concept).

> **Note:** The concentration of air traffic around airfields (arrivals, departures and transits) will continue to mandate the need for specifically designed airspace volumes dedicated to terminal area operations, including protection for climb and descent profiles (currently TMAs).

In MAS, the responsibility for SA will rest with the ground ATM organisation. This service will be provided on the basis of 'intervention by exception' as far. In some specific traffic situations the responsibility for separation may be explicitly transferred to aircraft suitably equipped to exercise autonomous separation, subject to the pilot's agreement (climb in trail, aircraft ahead, etc.). The provision of ground services to aircraft operating in MAS will encompass the full range of ATS: Flight Information Service, Alerting Service and an ATC Service.

The overall boundaries and route structures in MAS will be defined by a collaborative and integrated airspace planning and management service. The service will have the responsibility for optimising airspace use across the entire ECAC region via long, medium and short-term planning layers and utilising the benefits of CDM and system-wide IM to produce final Daily Operations Plans (DOP)s. The structure will be flexible enough to accommodate demand in terms of both traffic density and the spread of aircraft capabilities.

The degree of traffic structuring applied will be predicated on the forecast and actual demand and will vary over time. In periods of low demand, such as at weekends and at night, the traffic structuring in MAS will be limited. Likewise, greater flexibility will be possible in the less congested airspace of some ECAC regions. Nevertheless, it should be recognised that to provide the capacity needed during the peak demand periods, portions of the ECAC airspace will need to be designated as MAS and have traffic structuring applied. Instrument Departures and Terminal Arrival Routes will continue to be needed in the vicinity of airports. MAS will encompass the following operations characteristics:

Structured Routes

Operations within structured routes, where these are still needed, will be optimised by using the benefits of RNAV and FMS (it can be foreseen that the airspace classifications will be reduced and harmonised over the whole of European Airspace - subject to conformance to ICAO regulations):

- route structures will be tailored to meet capacity demands, to accommodate traffic flow variations, to take advantage of the release of Special Use Airspace (SUA) and to satisfy operational needs;

- route structures will be dynamically sized, providing IFR flights with more operational flexibility and, at times, freeing up airspace for VFR flights;

- routes structures will be better optimised to increase flight economy;

- sectorisation will be based on traffic flow demands, traffic flows complexity and workload factor considerations, without being restricted by national boundaries;

- the capability of flights for more accurate navigation and the improved predictive ability of airborne and ground-based systems will enable the current horizontal separation standards to be reduced, enabling the definition of more closely spaced routes and so contributing to increases in the capacity of the airspace;

- sectors will be optimised and be dynamically adjustable to provide the best balance between size and controller workload.

  Notes:

  1. The service provided by the future ATM network will encompass aircraft with differing navigation capabilities. Less efficient route structures would exist for less equipped aircraft in order to avoid penalising the more capable aircraft. It is anticipated that the pressures to increase flight efficiency will have encouraged all aircraft to be equipped with 4-D navigation capabilities.

  2. To airspace users, the detail of most of these improvements will be transparent, what they will notice is the reduced workload in communicating with the ground, increased flight economy and increased freedom of flight.
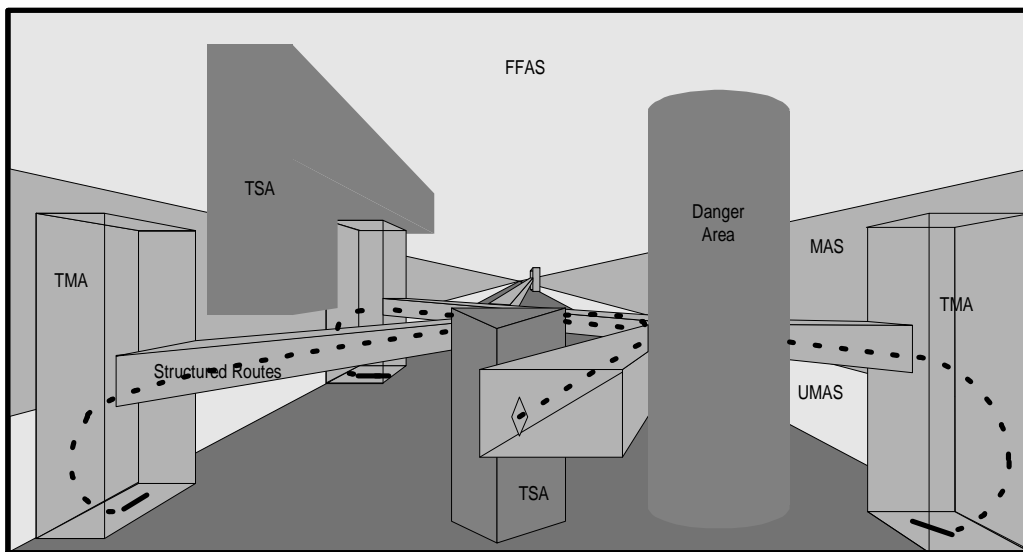
Structured Routes

Free-Routing

Free-routing operations can be seen as a development of the current practice of allowing flights to take up direct routing. Aircraft will fly their own user-preferred trajectories (subject to any overriding airspace restrictions) outside the structured routes but in a 'known' environment (their identity, position and intentions are known). ATM intervention will be by exception and will utilise the principles of CDM to determine and agree the best course of action for flights.

The development of automated support systems in the air and on the ground, coupled to new procedures and working arrangements in ATM, will permit the use of Free-routing in MAS and so provide significant benefits in flight economy and flexibility for users.

The best trajectory between the same two places may change from day-to-day because of changing airspace restrictions, the differing priorities of the aircraft and by the vagaries of the weather and other traffic. Traffic flows on a day-to-day basis will be broadly similar, likely congestion or confliction points will be determined as data on flight plans are analysed and collated with the Meteorological data from ground station forecasts and in-flight now-casts (using automated support tools). Centre supervisors will then be able to implement the best sectorisation plan to match the traffic pattern and to optimise sector loading or to adopt control operations on a flight-by-flight basis.
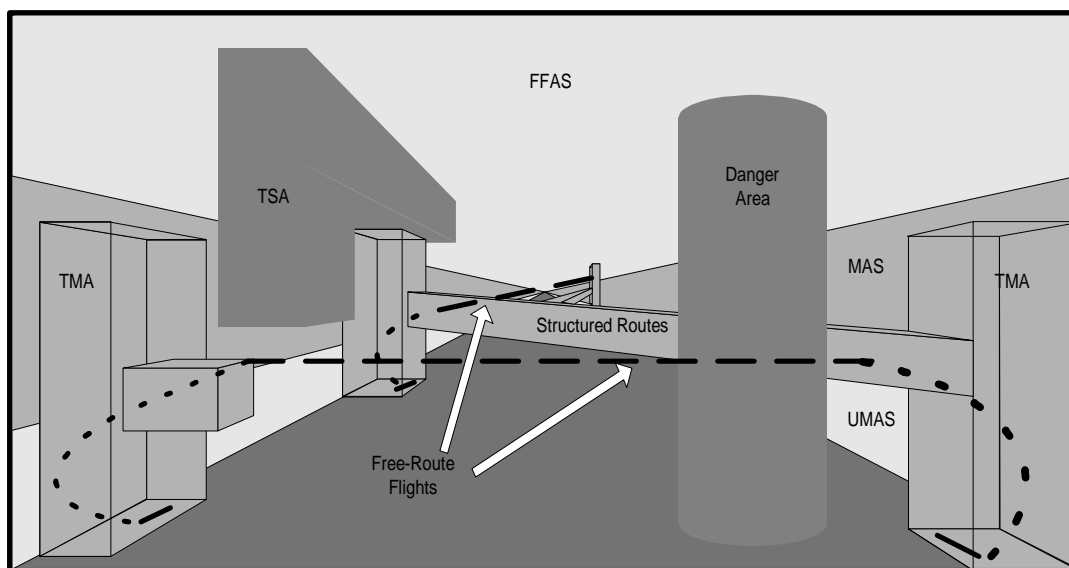
Free Routing

TMA

Operations within TMAs will vary according to the complexity of the airspace, the amount of traffic they have to accommodate and the number and complexity of the airports within their areas. In principle, the emphasis will remain on the establishment of RNAV and FMS routes but, with the development of tactical flexibility to accommodate other routings, dependent on the level of traffic density. As a baseline, the TMA of the future will be characterised by:

- flexible routes with dynamic route restructuring and TMA re-sizing in response to traffic flow so as to use only the airspace necessary to satisfy operations;

- closer separation standards and routes (enabled by more accurate navigation and monitoring capabilities);

- more accurate weather data from forecasts, now-casts from flights, and from weather detection radar, that can be analysed via improved meteorological services to assess the cost-benefit of different flight routings;

- aircraft with 3-D and 4-D navigation capability with RNAV and ASAS, some with the ability to accept responsibility for self-SA;

- the ability to collect accurate data on aircraft positions and intentions (via dynamic flight plans and from the aircraft's FMS);

- improvements to airspace planning in which conflicts have been designed out, including the problems caused by the mix of traffic with different capabilities (in equipment or performance capability);

- the assistance of integrated Departure/Arrival Management Systems (DMS/AMS) of other airports and with its own airport will permit when appropriate:

  1. accurate monitoring of flights and their conformance to their planned trajectories;

  2. improved prediction of 3-D trajectory information, based on more accurate data from ground-based surveillance systems and from flights;

  3. integration of weather actuals and predictions for determining optimised routes;

  4. integration with other DMSs in the same TMA, or to provide a departure service to multiple airports co-located in a single TMA;

  5. integration with En-route ATM systems.

Note: In complex TMAs with very high traffic levels, because of the overriding need to ensure adequate throughput and safety, a number of constraints will probably still affect aircraft operations by limiting the flexibility of dynamic route or routing change ability and constraining an aircraft's desired trajectory.

In those TMAs at which the ground organisations are fully equipped with the appropriate technology and controller support equipment, the capabilities of equipped aircraft will be realised to the full. They will be able to define their own departure routes or routings before departure, constrained only by the needs of safety to avoid hazardous areas and to satisfy climb-out noise abatement and environmental requirements.

Free Flight Airspace (FFAS)

The volumes of airspace that will be allocated to FFAS will be promulgated by the airspace planning and management service[19] on a daily basis to reflect the demand patterns expected across the ECAC airspace. This will take into account the forecast traffic flow densities, the capabilities of flights and the balance of benefit to the users' quest for flexibility and economy. The aim will be to adjust the volumes of FFAS to maximise the benefits for capable aircraft, while providing an incentive for aircraft operators with less capable aircraft to upgrade their avionics fits.

Suitably equipped aircraft will be able to fly user-preferred 3-D or 4-D routings. Responsibility for SA from other aircraft operating in the same airspace will rest with the aircraft in almost all circumstances, although some responsibility can be undertaken by ground-based ATM (emergencies) or delegated to other organisations (principally the military). Access to this airspace by less capable aircraft will be subject to acceptance by the ATM services[20]; access by capable aircraft is implicit.

Aircraft will be able to choose their own trajectories, selected either for short-term, long-term or strategic reasons, in which aircraft operators will benefit in terms of economy and flexibility, subject to notification to ATM, in which CDM and IM will be major enablers to safety, flexibility and efficiency.

Aircraft operating within FFAS will be supported by a ground ATM network that will provide information and alert services to guarantee safe operations, including degraded mode operations, these will be:

- a Flight Information Service:

    1. on request;

    2. providing precautionary anticipated information if specific local areas are predicted to be too congested for safe airborne SA (due to the eventual potential limits in the multiple-conflict resolution capability of ASAS equipment and the ground-based ATM network's more extensive knowledge of aircraft positions and intentions (derived from flight plan and computer-supported trajectory monitoring);capability of ground-based ATM element to oversee operations, originated by more extensive knowledge of aircraft positions and intentions (derived from flight plan and computer- supported trajectory monitoring);[21]

    3. to assist any flights which may get into difficulties ;

- an Alerting Service.

---

[19] This will be a collaborative and integrated function. It is axiomatic, therefore, that ATCUs will have been consulted in the determination of the FFAS parameters applied.
[20] The parameters for access by State aircraft are defined in section 6.13 at the end of this chapter.
[21]Aircraft will be in a 'known' environment, since their planned trajectories will have been notified to ATM and they can be expected to be in stable trajectories (FFAS is not 'ad-lib' airspace and high-energy manoeuvres are not compatible with the needs for economy or passenger comfort).
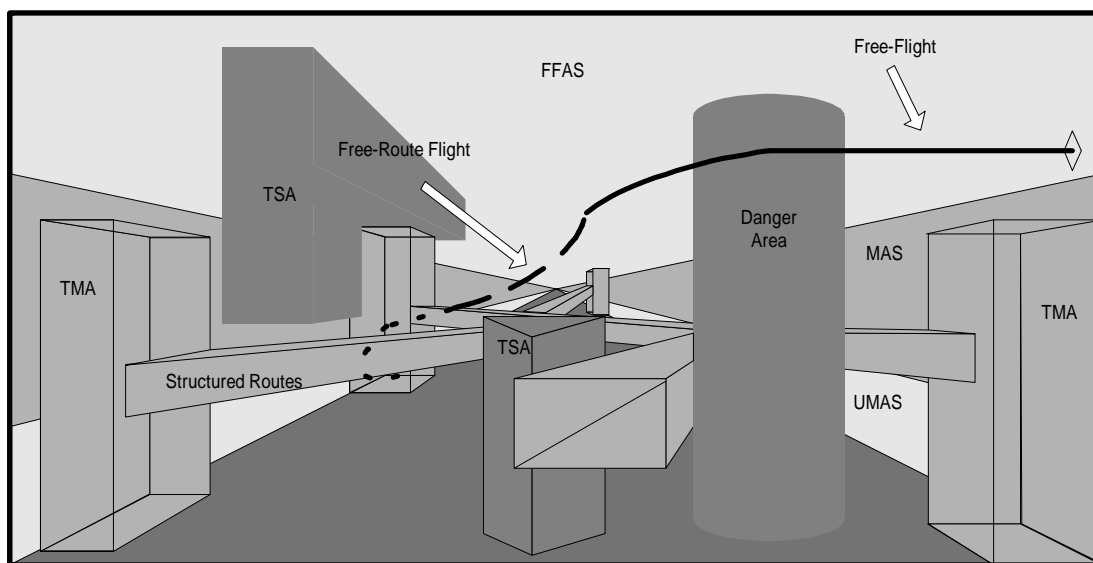
Free-Flight

6.8   Air Traffic Flow Management (ATFM)

ATFM is the current ICAO terminology for F&CM. It reflects the principle that ATFM currently exists to support ATC in preventing any system overloading and ensuring an optimum flow of air traffic to, from, through, or within defined areas during times when demand exceeds, or is expected to exceed, the available capacity of the ATC system. Available capacity includes the declared capacity of relevant airports.

Flight punctuality and efficiency[22] are two of the main factors which will drive the future ATM design and that will contribute to the definition of the quality of the services that it will deliver.

F&CM within the ECAC Region

The emphasis will be on responsive capacity management, with demand management applied only as a result of physical airport or airspace limitations, unexpected events or abnormal traffic peaks. F&CM will be a significant means of ensuring flight punctuality and efficiency. Required performance of the system will be part of the service quality contract. Implementation of that contract will be supported by the use of planning and scheduling functions. The main principles include co-ordinated time-tables, optimised time of arrival and minimum in-flight delay.

Context

A major objective of the concept is to develop the airspace capacity to such an extent that flow regulation will only be needed in exceptional circumstances. In this context, the emphasis of F&CM will move from adapting demand to a fixed capacity limit, to optimising the capacity of the system to meet the predicted demand.

An important consideration is the limitation imposed by airport capacity. While every effort will be made to optimise available airport capacity, the continuous growth in demand will continue to exert pressure on several airports. F&CM's prime objective will be to optimise the use of scarce airport resources by the tactical management of arrival and departure flows.

Another requirement for F&CM stems from autonomous aircraft operations and free routings, which implies a need to determine and manage the areas where such operations can be accommodated, or no longer sustained at specific times.

---

[22] Efficiency also refers to the capability of the ATM services to adhere as closely as possible to the intended flight trajectory requested by the user and expressed through flight planning.

F&CM will deliver an increase of capacity during both normal and abnormal situations by:

- the use of advanced air situation displays and support tools to provide a real-time picture of the traffic situation in ECAC airspace;

- improved collaboration between the ATM system, Airports and the AOCs for flight planning. Airspace users will have a greater say in decisions on those occasions when compromises have to be found between delay, re-routing, or trajectory limitations and costs. This will improve the opportunities to optimise trajectories, help minimise delays and the occasions when additional route mileage has to be flown, enhance fuel loading assessments, and offer more flexible and responsive solutions to the needs of flight operations;

- the capability to maximise the use of the available capacity and achieve a closer alignment between the aircraft operators short-term changes and ATM by the tactical choice of alternative routes (together with indications of the penalties associated with each) in order to reduce delays, to avoid congestion points, to reduce the need for strategic routing schemes and the number of instances of significant system overload;

- the development of more effective measures for dealing with unusual situations, such as significant outages in the ATM system.

The Service Quality Plan

The main concept elements related to F&CM are :

- the Service Quality Plan which defines the quality of service that the future ATM network has to deliver to each user;

- a layered set of planning and scheduling functions for preparing, co-ordinating and managing the service quality plans.

The service quality plan will define the specific user demand, the quality of service to be achieved, and the planning responsibilities of each party. These plans will form a central platform for the strategic planning activities. For the airspace users, the plan will ensure that any commitment to provide specific level of flight services is accompanied by an equivalent commitment from the airport and ATM service providers.

The airport operators and airspace users will play the major part in the elaboration of the service quality plans and ensuring the necessary balance between demand and the airport capacity available. However, involvement of the ATM service providers in the process remains necessary to ensure their commitment to provide the required quality of service.

Managing the Service Quality Plan

As part of the required quality of service, flight punctuality and flexibility will be optimised through the use of scheduling and planning functions. The main principles include co-ordinated timetables, optimised arrival times and minimal in-flight delays. Declared airport capacity will be a major factor in deciding these. In addition, standard contingency plans will be developed at the scheduling and planning stage to ensure that localised airport-related capacity reductions (for meteorological or other reasons) will not cause ripple effects elsewhere in the ECAC region.

F&CM will incorporate a layered planning system, with each layer operating as a filter for the next, in order to optimise the resources needed for a particular day's operations.

The process will involve:

- Strategic Flow Scheduling;

- Optimal Flow Regulation;

- Tactical Flow Planning.

The requirement for flight plans or other media to provide notification of intentions will remain, but in the tactical planning phase these will contain more extensive details of the intended trajectory to be flown by the aircraft.

The process will involve close co-operation between the parties involved: the F&CM body, the aircraft operators and their AOC, the airport operators and the ATC service providers. The degree of information integration will be a determinant in the roles and flexibility given to individuals.

Key Issues
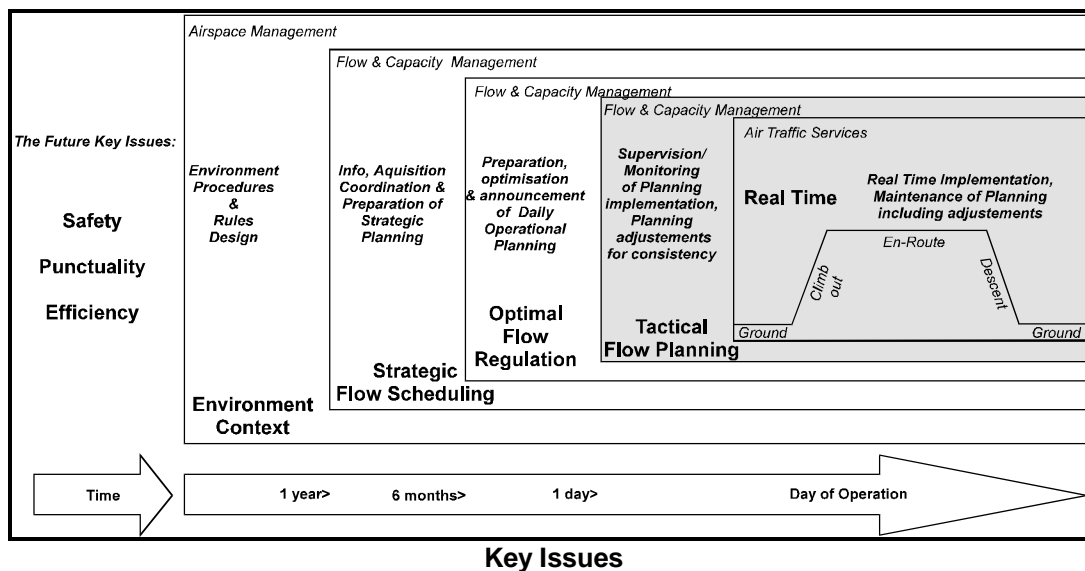
Strategic Flow Scheduling

The need for strategic flow scheduling emanates from the need for the airlines to publish their Summer and Winter timetables well before the beginning of each season. This is the stage at which individual airlines position themselves in the travel business market, and adjust their route network requirements to the demands of the travel industry. One of the drivers for the publication of the timetables is the need of the travel industry to define their holiday packages, buy capacity on flights to selected destinations (on charter as well as scheduled flights), and to start taking early bookings. Based on declared airport capacity and statistical information concerning weather conditions at airports, traffic flows will be optimised to provide acceptable scheduling (i.e. a timetable) and facilitate the agreement of service quality plans with the users.

The optimal airspace configuration will be defined from the consolidated picture of the forecast ECAC traffic flows. This will enable the preparation of strategic measures to create the corresponding capacity.

The output of the process will be a set of Daily Operations Plans (DOP)s that will balance the expected demand and forecast available capacity.

Optimal Flow Regulation

There will still be changes to timetables following the strategic planning phase, and aircraft operators will plan flights which have not already been captured. The role of Optimal Flow Regulation will be to refine the details of the original plan over time and to prepare and promulgate an optimised and detailed operational plan one day in advance of the implementation date (e.g. airspace configuration(s), forecast flight operations and types). Optimisation planning will require detailed analysis of the expected traffic levels and available capacity using advanced simulation tools, and will determine the airspace and systemisation configurations to be used.

Tactical Flow Planning

The role of Tactical Flow Planning will be to implement and supervise the DOP, and to apply any refinements needed in the light of real-time events. The intention will be to ensure as little disruption to the daily airspace plan as possible, and any real-time corrective measures will follow

this aim. The need to adapt the original plan may result from significant weather phenomena, industrial action, or unexpected ground or space infrastructure outages and predicted limitations.

Tactical Flow Planning will act in a supervisory role, and make full use of all available information facilities to monitor and anticipate adjustments to the plan in terms of the most efficient configuration of resources. If delays are unavoidable, an equitable re-partition will be negotiated with the airspace users affected. When necessary, a ground holding strategy will be applied to avoid costly airborne delays.

ATC units will co-operate with Flow & Capacity Management and the other parties involved to implement and maintain the DOP.

6.9 Air Traffic Services

Traditionally, ATS have always had a leading role in progressing, developing, maintaining and managing the overall actions related with the provision of services required to manage, maintain and regulate the safety of air traffic. However, the recent forecasts of traffic increases led ICAO to give greater importance to the concepts of Airspace Management and ATFM as complementary to ATS.

The understanding gained and the reasoning used during the development of the target OCD, indicates that the role of ATS will not change in the future, and will continue to be the most important element of ATM due to the safety implications of the services provided. However, the other ATM components will gain in importance. ASM and ATFM roles will be to anticipate, identify, organise and prepare the implementation of strategic planning in order to provide a high quality of service to the airspace users and to minimise the tactical implementation risks related to real-time operation.

It is not anticipated that the goals of ATS will change in general terms. However, the daily operation, corresponding procedures and particular roles will have to evolve, in order to be able to respond promptly to real-time scenario variations and to maintain high levels of performance and productivity without jeopardising air traffic safety and the Quality of Service.

Where applicable, the following ATS will form the primary elements of the ATM service provided in the ECAC region:

- ATC Service;
- Flight Information Service;
- Alerting Service.

ATS will benefit from advanced and integrated data information exchange and computer support. The main aim of the ATS will remain principally in line with today's services, but with emphasis on ATC.

ATC Service - The objective of ATC is to maintain a safe, expeditious and orderly flow of air traffic. Specifically, its purpose is to:

- prevent collisions between aircraft and between aircraft and obstructions on the manoeuvring area. This function will evolve to ground-based flight safety management, including safety monitoring and SA, within the parameters of gate-to-gate operations and covering the rules governing the operation of the airspace regimes;

- maintain an orderly and expeditious flow of traffic. This function will evolve to a traffic management role encompassing implementation and maintenance of the DOP, and include the provision of sequence management.

In the context of the implementation and maintenance of the DOP, ATC will be responsible for maintaining a safe, expeditious and orderly flow of air traffic on gate-to-gate principles, and for converting asynchronous traffic flows to synchronous flows prior to landing.

Flight Information Service - The objective of the Flight Information Service is to provide advice and information for the safe and efficient conduct of flights. This service will be complemented by a trajectory monitoring service (which will be progressively automated) to maintain situation awareness in the event that an aircraft requires assistance from the ground. Flight Information Service will be provided within MAS, FFAS and within UMAS upon request.

Alerting Service - The current purpose of the Alerting Service - to notify appropriate organisations regarding aircraft in need of search and rescue support and assistance, will remain largely as it is today, but will benefit from the availability of more timely and integrated information.

6.10 Aeronautical Information Services

AIS collect and disseminate information relating to the structure and composition of the ATM physical environment and thereby provide essential support for virtually all aeronautical activities and programmes. The objective of AIS is to ensure the satisfactory flow of the information necessary for the safety, regularity and efficiency of international air navigation. AIS in the ECAC region will be improved and developed to provide a harmonised, co-ordinated service delivering quality-assured information to all phases of flight, both in the context of the gate-to-gate concept and in support of CNS.

The establishment of a common, harmonised approach to AIS service levels along with the integration of briefing facilities will provide a uniform, enhanced service to the airspace user. The so-called 'One Stop Shop' for information will seek to provide the airspace user with a single-point access, not only to AIS, but also MET, flight plan and other related information, providing combined automated pre-flight and in-flight briefing facilities. In particular, the in-flight phase will involve the use of datalink to provide products such as in-flight briefings, NOTAM updates and onward flight briefings.

One of the key objectives of automation in AIS is to establish a 'Paperless AIS', incorporating the use of electronic Aeronautical Information Publications and Charts. Of significance to AIS providers and users alike, this will be achieved by establishing uniform presentation of AIS data through a range of media which will include the world wide web. The automation process relies heavily on the establishment of harmonised operating procedures for both static and dynamic AIS data.

6.11 Meteorological Information Services

High quality meteorological information is a pre-requisite for a safe and efficient ATM network as a basis for pre-flight CDM and calculation of trajectories, taking winds and other hazardous weather phenomena such as turbulence and icing into account. The meteorological community will remain the backbone for the provision of meteorological products to the aviation community.

Weather observation at and around airports will continue to be improved. Aircraft will provide the meteorological community with down-linked in-flight measurements. Thanks to the combination of better meteorological models, continued growth of computing power and the availability of additional, more accurate and more up-to-date inputs, the meteorological service providers will be in a position to deliver improved aviation weather products.

Textual as well as graphical weather information will be up-linked via datalink to the aircraft. The data will be integrated with other information in the cockpit and complement the data coming from on-board weather sensors. Also, on the ground (AOCs, F&CM, ATC, airports), weather information will lead to more optimised decision making, particularly through new functionality in various software components which will be able to fully exploit this type of input.

6.12 Airports

Arriving at an acceptable common solution for airports is difficult because each airport is different, in terms of size, surface area, number and configuration of runways, number of terminals etc. The levels of sophistication of automated support and the information systems available varies, as does the range of facilities for passengers and airlines. Also each airport operates under different

conditions; environmental, commercial, political and weather. Additionally, the organisation and division of responsibilities can be significantly different, causing different operational priorities at different airports. For these reasons, airports has been considered as separate entities in the past. However, in the future system, airports have to be seen as an integral part of ATM and nodes of the air transport network, and for which a common assessment of capacity is needed.

The future ATM network will ensure that en-route ATM is not a constraint on future air transport growth. However, not all airports will be able to cope with the increase in demand. Therefore, good practice for maximising the airport capacity[23] must be used in a systematic way across Europe.

Airport capacity in low-visibility conditions requires particular attention, and measures, such as enhanced vision systems and new concepts and procedures based on emerging technology will be applied. In addition, the application of reduced vortex separation minima in certain defined conditions will increase the runway throughput. This, with operational changes to airport surface management including the introduction of Advanced Surface Movement and Guidance Control Systems (A-SMGCS) and changes to procedures, will improve the management of ground movements, airport traffic situational awareness, ground conflict detection and alert and ground traffic guidance.

The integration of A-SMGCS with combined arrivals and departures management systems, the use of RNAV techniques, the gradual introduction of the future ICAO precision landing aids using satellite navigation information, optimised traffic routes around airports, and more integrated schedule planning between adjacent airports, will provide improvement in all-weather operations[24] and capacity will begin to match that for operations in good visibility conditions. This will be achieved taking full account of the airport environmental issues.

A pro-active collaborative process between the States, airspace users, airport operating authorities, service providers and manufacturing industry will be the rule. Improved planning procedures and early and continuous dialogue between the airport operators and ATC (airport and en-route) and ATFM stemming from enhanced IM and more integrated systems will help to ensure that resources at capacity constrained airports are used more efficiently. Longer-term planning processes will seek to balance aircraft operator schedules and forecast airport capacity. Timely and shared information on real-time events will enable faster and more informed decision making on how to fill potential gaps in take-off and landing slots, and allow traffic to be adjusted to meet the new requirements. Together with improved surface management, the integration of data and CDM will facilitate improved gate and ramp management, and have a positive impact on flight punctuality and inter-connections, particularly at hub airports.

However, the overall system will have to remain flexible enough to handle airport, ATC and airline operators operational situations (e.g. problem of delays generated by a broken tow-bar during push-back, taxiway bypass by ATC due to an aircraft stopped to sort out a brakes problem).

6.13   Military Aspects

The Operational Concept for the future ATM network incorporates the high level operational requirements of Military Aviation. These include the recognition that the military users of ECAC airspace carry out operations that do not comply with ICAO or individual national aviation rules or procedures for GAT. To ensure that military interests in ECAC airspace are adequately safeguarded, there is a need for the future ATM network to recognise and make provision for them. The aspects that will have to be addressed during the future development of the concept, some of which are examined in more detail in Annex A Appendix 4,"Military Aviation's Viewpoint") are:

---

[23] Airport capacity needs a centralised assessment and can be considered at the strategic and tactical planning levels:
  - Strategic: the number of movements the airport can operate in good and normal weather conditions,   - Tactical: the number of movements the airport can operate taking into account the most common weather conditions for the period considered, as derived from statistical analysis, the statistics of the environment (aerodrome configurations) and equipment availability or the anticipated knowledge of potential real-time conditions for a certain period.

[24] The term all-weather operations should be understood in the current context to refer to normal weather conditions, with the exception of snow storms, cumulo-nimbus and thunderstorms.

Sovereignty - Within the context of the future ATM network, States will retain the right to assume the responsibility for the provision of ATM services within their territorial airspace.

Air Defence - Provision is required to accommodate operational Air Defence missions with the appropriate priority, as well as those operational missions by State aircraft that require priority e.g. SAR missions.

Training and Exercises - Military and State aircraft will need to be able to reserve airspace for training or exercise activities.

State Aircraft Flying OAT - OAT operations are a crucial element of military activity and they should be able to be conducted in any of the proposed airspace regimes. These operations need to be supported by efficient and effective civil/military co-ordination both at a procedural and system level. The rules applicable to these operations will be promulgated nationally although it is expected that they will have been co-ordinated for harmonisation within ECAC between the civil and military authorities. A principal objective of the concept is to treat the airspace as a single continuum and consequently, the conduct of OAT should also be as "seamless" as GAT.

State Aircraft Flying GAT - Not all State aircraft will be able to comply with civil GAT procedures and there will be a need for agreed operational or technical waivers, and, in exceptional cases, special priorities may be requested (e.g. a degree of confidentiality for some flights).

Other Military Airspace Users - There will be continuing requirements for airspace reservations generated by military non-flying activities that will require other aircraft to remain clear of those portions of airspace (e.g. ground-to-air and ground-to-ground firing, high-intensity emissions etc.).

Systems Interoperability - The national, NATO and other Air Defence Command and Control Systems' requirements to build a Recognised Air Picture (RAP), where applicable, will become more critically dependent on access to high integrity real-time flight data. In addition, the implementation of civil/military initiatives such as FUA will also require the capability for data exchange.

Security - The interoperability of military and civil systems, and the use of shared information, raises institutional and systems architecture issues in the need to ensure that the security of military data is adequately protected within the future ATM network.

6.14 Environmental Issues

The role played by air transport in socio-economics is recognised world-wide as fundamental to the progress of modern society. However, there is considerable concern regarding aircraft noise, fuel burn and gaseous emissions, which have an increasingly negative environmental impact.

Gate-to-gate, as foreseen within the target concept, is associated with developments on airspace organisation and structure, either en-route or on the approach/departure paths at airports. Improvements brought about by more adequate management of the air traffic evolving at the airports surface, complemented by CDM measures and supported by corresponding institutional issues, will be a major step in contributing to significantly reduce fuel inefficient routings, airborne/ground holdings, non optimal flight profiles and noisy approach/landing and take-off/departure procedures.

6.15 Role of the Human in the Future ATM network

Transition and Change Management - The management of human resources, and the relationship between the human and the machine in regard to responsibilities for separation, will be two main subjects for strategic action.

Since human performance is a crucial component of ATM, human involvement and commitment issues will be analysed and documented throughout the concept transition process. This is necessary to ensure commitment and ownership of the significant changes that will occur in the relationship between the two.

The Role of the Controller in the future ATM network - Future provision of ATC will be under-pinned by service quality plans and greater predictability of demand. Development of the future ATM network will not be technology-led and the aims will be to develop systems to solve current limitations, to sustain the forecast operational changes and to prepare a smooth transition to the challenges of the next century.

Current R&D activities focus on those capabilities of the controller which can be analysed in cognitive and behavioural terms. At present the most important cognitive processes of the multiple tasks conducted by the controller are the perception of information, information selection, information integration, planning, and decision-making and the maintenance of a mental picture of the air traffic situation (situational awareness). A major issue in this area will be whether or not it is possible, with a change of roles, to rearrange the situational and cognitive elements which feed awareness so that a controller only has to keep a mental picture of a limited portion of the overall traffic situation.

The trend will be towards the evolution of a new working environment in which task sharing aims are focused on enhancing the differing strengths of human and machine and minimising their limitations, rather than using machines to replicate the controller's current tasks (an analogy can be drawn with the impact of the relatively recent introduction of 2-D radar information within the controller's work environment when compared to the previous procedural methods of working).

The concept incorporates an evolving change to the current ATM environment in respect of roles and responsibilities, both on the ground, and between the air and the ground ATM elements. The greater use of computer support tools to facilitate FFM operations, and a move to more dynamic airspace structures will lead to the re-allocation of tasks and responsibilities. Human-Human and Human-Machine task sharing will be employed both on the ground (in the control team), and between the air and the ground (between the flight-crew and control team). Only the evaluation of realistic task sharing within new environments can determine the impact on the current human role, and what measures will be needed to allow the human to retain the ultimate responsibility for real-time aircraft separation. The types of ATC organisations best suited to the future ATM network, including flexible and dynamic multi-sectors and planning, will be selected to best suit the traffic patterns and the provision of safe services, while matching the human factor requirements. Several options are possible. These are not necessarily mutually exclusive and are the subject of on-going investigation.

The Role of the Pilot in the future ATM network - The role of the pilot will evolve as a consequence of the:

- increasing role of the AOC in real-time fleet management and flight programme handling; in particular for hub operations and the determination of user-preferred trajectories;

- transfer of responsibility for separation to the flight-crew in FFM will introduce new factors in aircrew-to-aircrew relationships. This will need careful consideration to determine the conditions under which this responsibility could be exercised (pilot workload).

There is a general requirement for flight crews to be more aware of the surrounding traffic situation and environment. Air-ground integration also calls for the evolution of both the air and ground ATC elements and flight operations to be developed in harmony and collaboration. In particular, the HMI will need to provide compatible air and ground representations of trajectories and the data determining the traffic situation.
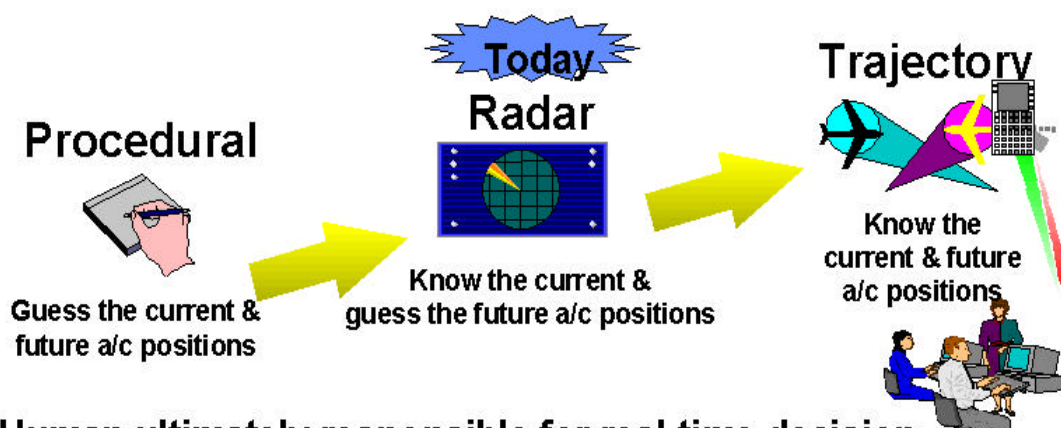
Evolution of Roles and Responsibilities

The roles and responsibilities of Controllers have evolved from knowing the last reported position of the aircraft (Procedural) to knowing, with the advent of radar, its current position (Radar Control). This evolution generated new responsibilities for controllers related to directing air traffic and, in some specific cases, moved the responsibility for navigating the aircraft and maintaining separation from the pilot to the controller.

One of the major contributions of automation will be the possibility of accurately anticipating the future position of aircraft. This new possibility is seen as an important issue that will contribute to generating capacity and providing flexibility.

Additionally, the use of datalink will also contribute to alter the means and substance of pilot /controller communications. Controllers will also have to adapt the mental models that drive their actions, as airspace restructuring progresses. Technological advancements will enable different hardware and software capabilities in the air and on the ground which all together will have new implications on the roles and responsibilities of Controllers and Pilots.

ANNEX A   GATE-TO-GATE SCENARIOS AND VIEWPOINTS

1.0   Introduction to the Scenarios

This Annex to the OCD is the first in a series of documents, set out as Scenarios and Viewpoints, that will describe the future target concept. Firstly, this document consists of a number of Scenarios describing the final state of the Target Concept Statement. Other series of Scenarios will be produced later that will set out the intermediate stages towards the target concept in line with those expressed in the Air Traffic Management (ATM) Strategy for 2000+.

The purpose of these Scenarios is, in support of the OCD and the ATM Strategy for 2000+ Strategy, to illustrate possible ways in which the target concept can be interpreted and to:

- assist the reader's understanding of how the target concept is intended to work, by covering how some facets of it could be applied to flights in European airspace and to explore what may be the benefits and similarities in comparison with today;

- provide the basis of guidance material for the work of R&D in support of the target concept.

There are many areas of development which will affect the target concept. Defined and agreed transition paths with set implementation objectives, cannot be achieved until the timings and applicability of the potential target concept components have been researched, validated or resolved. The scenarios produced are a collection of assumptions rather than a definitive forecast. They will therefore, be subject to revision over time and will certainly prove to be inaccurate in a number of areas as the results of R&D and concept validation work become known.

1.1   Achievements to Support the Target Concept

The target concept will be built on the achievement of a number of improvements by which ATM capacity will have been increased so that aircraft in Europe will be able to operate as freely and efficiently as possible. Demand management will only be needed to deal with exceptional physical restrictions or severe weather events. Although some improvements will be common to all areas of Europe, because different areas may have different needs, not all of them will be present in each area.

The improvements are categorised as a number of elements under the headings of: Airspace, Planning, Systems and Co-operation. It should be noted that the close interaction between the activities of ATM means that a part of each category is present in most of the elements:

Airspace

- the development of RVSM and RNAV techniques;

- reductions in horizontal separation standards;

- improvements in airspace and route design to allow sectors and routes to be better aligned so as reduce the complexity of conflict situations (this will need inter-State agreement to remove current FIR boundary constraints);

- definition of ATS route structures in three dimensions, so as to reduce controller workload;

- Free-Routing to increase airspace users flexibility, reduce flight time and reduce aircraft emissions;

- the introduction of Autonomous Aircraft Operations to further expand on airspace users flexibility and on economy of operations.

Planning

- the use of enhanced planning during all phases of flight;

- a "layered" scheduling and flow planning system to maximise the utilisation of the available capacity across the ATM network as a whole;

- longer-term planning of aircraft trajectories so as to reduce the number of conflicts at the tactical level;

- FUA, allied to sectorisation changes and the integration of civil/military airspace planning, will contribute to effective collaborative planning involving all European airspace and so increase flight efficiency and the use of actual available airspace.

Systems

- controller working conditions will have been improved by the use of advanced computer support tools (for conflict prediction and trajectory planning), upgraded human-machine interfaces and work positions;

- major airports will have the capability for all-weather operations and be able to optimise traffic movements by the use of integrated Surface Management Systems (SMS)[25] for ground planning and control;

- Arrival Management Systems (AMS)s and Departure Management Systems (DMS)s will be integrated with each other, with the Airport SMS and elements of ATM in support of gate-to-gate operations;

- ATM systems in the different States will be inter-operable and Flight Data Processing Systems will be upgraded to support advanced data processing, Free-Routing and Autonomous Aircraft operations;

- full ATM communication networking and data exchange capabilities will make it possible to upload and down-load computer-generated flight plans, including taxi, departure and approach plans;

- ground communication environment upgrades, allied to the extended use of common data protocols, will have created a more cost-effective and efficient IM infrastructure;

- navigation, safety and surveillance will be improved by the use of GNSS2, Mode S, Basic and Precision Area Navigation (B-RNAV and P-RNAV) RNP 5, RVSM, ASAS, ACAS and FMS capabilities;

- service providers and users will be equipped with the cost-justified technology to support safe and efficient flight operations;

- the CNS/ATM infrastructure will be optimised (obviously, until R&D results, requirements, economic and political influences are decided we cannot say what equipment it will be).

Co-operation

- more efficient operations will be enabled by the transfer of some separation responsibilities from the ground to the air in MAS and the introduction of autonomous aircraft operations in FFAS;

- there will be greater co-operative interaction between users and service providers, realised through the benefits of IM, which will make available all the data needed to ensure efficient operation and to realise the full possibilities of CDM;

- common regulations and procedures will have been adopted throughout Europe to minimise the problems of different local procedures in which the unification of European-wide airspace regimes will serve to provide transparency to the users;

---

[25] SMS will incorporate airport Surface Movement Guidance and Control Systems (SMGCS) and new systems and tools currently under development or being researched.

- improved capacity management and procedures, and the involvement of AOCs and Airports in the ATM planning processes, will lead to full gate-to-gate planning and conduct of flights.

1.2 Scenarios

The Scenarios are arranged as a series of descriptions of the concept as seen from the viewpoints of various stakeholders and presented as an Annex. The scenarios are divided into 3 categories by which readers with a particular interest can see how it is foreseen that future concept will affect them. Reading all scenarios will give a fuller picture of the nature of the target concept and future ATM network.

The scenarios cover the majority of (but not all) operations, illustrating activities in the air and on the ground in support of the safe conduct of flight operations. They focus on:

1. Flight scenarios from a flight-crew viewpoint recounting the progress of two flights:

   Appendix 1   A commercial IFR flight operating in Free-Routing and Free-Flight mode;
   Appendix 2   A commercial IFR flight operating entirely in MAS.

2. Flight viewpoints describing the interactions between the ATM network and:

   Appendix 3   General Aviation's Viewpoint;
   Appendix 4   Military Aviation's Viewpoint.

3. Ground viewpoints illustrating the activities roles and responsibilities of major users and service providers:

   Appendix 5   Planning Viewpoint;
   Appendix 6   AOC's Viewpoint;
   Appendix 7   Controllers' Viewpoints;
   Appendix 8   Flow Management's Viewpoint;
   Appendix 9   Essential 'Future ATM network' Enablers;
   Appendix 10   Systems' Viewpoints.

1.3 Safety

Safety considerations are fundamental to ATM. Safety is defined in operations activities as SA. SA is the process of ensuring that flights remain clear of each other and of other hazards to their safety (the ground, ground obstacles, danger areas, prohibited areas, SUA and adverse weather). SA is applicable, in different forms, to all layers of ATM, from initial planning on the number of flights that can safely operate into and out of an airport, through controller's clearances for a single flight and finally to the flight-crew themselves.

Flow Management provides a first-layer planning and control element that helps to ensure an efficient overall traffic flow and which uses all resources to best effect. It does this in an upgraded CFMU capable of balancing the capacity of the airspace and the available resources to optimise traffic flow. It will also manage the traffic flows across European airspace by co-ordinating with AOCs, En-route Centres, and departure and destination Airports to apportion traffic. This will ensure a manageable workload for controllers and assist in the avoidance of adverse weather.

Flow Management also provides the second layer, operating on an overall picture of active traffic when the uncertainties in the first layer are reduced by the knowledge of actual flight times. Here FMs will sequence and separate flows of traffic and balance capacities. They will do this by examining the overall traffic picture to identify where traffic congestion may cause overloading of resources in Centres to occur, or where developing weather may cause a problem. They will then, in co-operation with the AOCs, flight-crews and Centres, regulate and reorder the traffic flows. They also, of course, will seek to optimise the traffic flow by taking advantage of the opportunities to shorten flight routings, for example by re-routing traffic through recently released SUA.

Centres provide, in the long to medium term time-frame, the third layer. **Centre Supervisors** will have access to the same data as that used by FMs and AOCs to obtain a picture of the current and forecast traffic flows and weather conditions throughout their area. They will then manage their resources and sector configurations to optimise the balance between service provision and controller workload. **The Multi-Sector Planners (MSP)s**[26], working in close co-ordination with Flow Managers (FM)s on the planned and current traffic, will use computer support tools to further manage and balance the complexity of traffic flow plans produced by the upper layers.

Sector and Terminal Controllers provide, in the short term, a fourth layer where control will be 'by exception' e.g. when changes to the flight trajectory need to be made. This could be to correct non-conformance to the flight plan or to resolve problems, caused by bad weather or another aircraft, mean that changes have to be made to a flight in the interests of safety.

The flight-crew provide the final layers. Firstly, the capabilities of ASAS will allow the delegation of some airborne separation tasks to the flight-crew, such as station-keeping and clearances to an aircraft to climb/descend/turn when it is 'clear' of another. Finally, in addition to SA, ACAS provides a safety-net to assist the flight to avoid other aircraft. These systems will be linked with the ground-based facilities to ensure that they do not themselves conflict or interfere with each others operations.
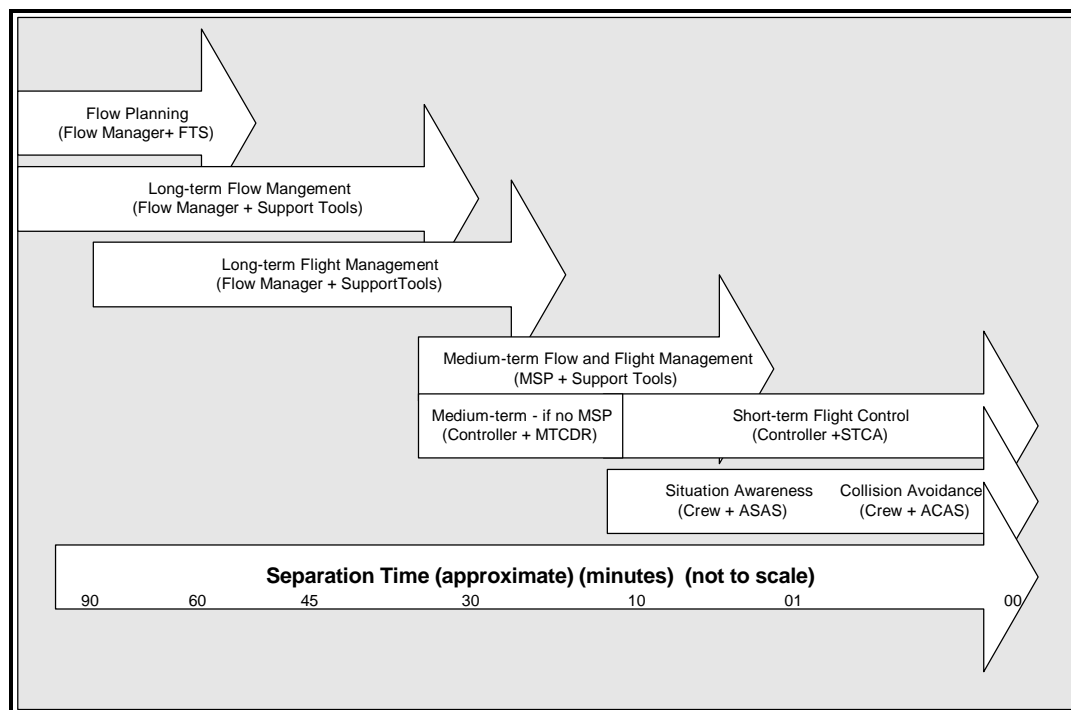
Safety layers

---

[26] See Annex A, Appendix 7 for a description of MSP functions.

Appendix 1   Commercial IFR Flight in Free Routing and Free-Flight

1   Scenario

The Flight is:

- an IFR commercial flight, belonging to a large airline;

- equipped with FMS, 4-D flight capability, Enhanced and Synthetic Vision Systems (EVS/SVS), ASAS, ACAS and Datalink;

- operating in Managed and Free-Flight Airspace.

The Airports are:

Departure	Arrival
large, high complexity	medium-sized, medium complexity
equipped with datalink	equipped with datalink
equipped with SMS, AMS and DMS	equipped with SMS, AMS and DMS
capable of all-weather operations	capable of all-weather operations
situated in a TMA	situated in a TMA

2   Pre-Flight Phase

The flight-crew start their involvement with the flight in the briefing office. The office is equipped with computing and communications equipment linked electronically to the AOC, to the CFMU and to ATM. Using the facilities, the flight-crew familiarise themselves and agree (in co-operation with the AOC) with the detail of the flight (e.g. the actual and forecast weather conditions, the airspace structures in operation on their route and their planned push-back and departure times).

The flight-crew validate the electronic copy of their flight plan, received from the AOC and which has already been negotiated and agreed between the AOC and ATM, and agree with its transfer to the aircraft's FMS.

> **Notes: For an airline without an AOC**
>
> 1. The briefing office may still be equipped with computer equipment linked electronically to the CFMU and ATM, but the functions of the AOC will be replaced by remote service providers who can supply the basic planning services (by the assembly of the data relating to planned area and time of operations of the flight) to the flight-crew.
>
> 2. The flight-crew will use the information provided to plan their flight and to estimate their push-back and start-up times, When ready, they submit their flight plan electronically to the CFMU. Because they do not have the time or electronic capabilities to make a detailed assessment of the factors affecting their flight, it is probable that it will not provide the best optimisation for their flight. Having a better overall picture of the air situation, an FM at the CFMU can suggest revisions to optimise the flight plan. Once any revisions are negotiated and agreed, the flight-crew then download an electronic copy of their flight plan, ready for transfer to the aircraft.

The flight plan of 2015 will contain a much more comprehensive description of a flight's intentions than it does today; principal changes will be in the quality and amount of data it holds and in the dynamic nature of its contents, such as:

- Route data will consist of 2-D reference points in World Geodetic System-84 format (WGS-84), allied to a z (altitude or Flight Level) co-ordinate to give a 3-D position (3-D fix) and, for 4-D flight, an associated time (4-D fix). The number of 3-D or 4-D fixes and the level of accuracy required for a trajectory will be determined by the need to ensure effective planning and safety);

- the flight and ground will have a complete electronic copy of the flight plan;

- the flight plan will be updated automatically in flight (via datalink) as necessary (avoiding action, trajectory alterations, re-routing etc.);

- more data on performance capabilities of the aircraft will be held, either on the ground or in the air, to allow for better trajectory prediction.

3   Ground Departure (Start-up)

When all briefing activities are completed, the flight-crew board the aircraft and complete their Pre-flight checks (including validation of the flight plan).

> **Note:** The availability of datalink facilities between the aircraft and ATM allows for a considerable increase of efficiency in information exchange between the flight-crew and the ground. Information that would otherwise be impossible or very time-consuming to exchange by using voice communications or Radio Telephony (R/T). Datalink has safety and productivity benefits in its ability to transmit long or complicated messages very quickly. If desired, any messages, clearances or instructions passed to the flight-crew may be printed to reduce the potential problems of misunderstanding, mishearing or forgetting. In addition, with the flight-crew's authorisation, complicated messages such as taxi route instructions can be loaded automatically.

The flight-crew have been aiming for a start-up time that has been agreed with the CFMU. This time takes into account an approximate time for getting to the runway, but the vagaries in passenger loading and other activities mean that there are always elements of uncertainty about the precise time that a flight will be ready. However, once the passengers have boarded the aircraft, the baggage, fuel and catering supplies have been loaded and the ground-crew have cleared the aircraft for departure from the gate, nearly all uncertainties have been removed.

The flight-crew next contact the Tower controller to obtain their start-up and taxi clearances via R/T.

The Tower controller, who had already received data about the flight from the ATM network uses automated planning tools (part of the SMS) to assess all actual and known planned movements on the Airport so as to be able to decide the best start-up time and the most efficient taxi plan for the aircraft to meet its planned take-off time (a more accurate time than now). The Tower controller passes the taxi plan (consisting of a time-scheduled route) by datalink and the start-up clearance by R/T to the aircraft.

4   Ground Departure (Taxi)

The flight-crew receive their start-up clearance and display the airport map data on their Cockpit Display of Traffic Information (CDTI). The CDTI also displays the identity, position and short-term intentions of other manoeuvring traffic (aircraft and vehicles) relevant to their flight. At the appointed time they start up, push-back and start to taxi along routes that have been designed to minimise or eliminate conflict between departure and arrival taxi streams and to ease potential queuing or congestion problems.

The weather is bad and the visibility is so poor that, using normal vision, the flight-crew can see nothing, or very little, outside the cockpit. They are assisted however, by EVS that allows them to 'see' in poor visibility, or SVS that gives them graphical representations of their surroundings either on a head-up display or on the CDTI. Interference to schedules caused by bad visibility is minimised for equipped aircraft and, unless the weather conditions really become too bad for safe operations, the same level of throughput is achieved as in good visibility conditions.

Notes:
1. Of course, not all aircraft will have EVS or SVS. In some cases the Tower controller can provide the aircraft with assistance for taxiing. Using ground-based active and passive detection equipment on and around the Airport, the controller will be able to monitor all airport traffic, guide an aircraft to its destination and, using ground-based systems, to provide position and intention transmissions as though they were from the aircraft.

2. In the information-rich environment all agencies that are responsible for ground movements on the airport will have the same information on the identities, positions and intentions of flights on the manoeuvring area as well as their own movements (vehicles and aircraft). This will give the opportunity for responsibility for separation on the airport surface to be shared between ATC and ground agencies (aircraft maintenance, fuel companies etc.). Flight movements can be the responsibility of Tower and Runway controllers and will have priority over all other movements (subject to safety) and the agencies will be responsible for co-ordinating their movements with the controllers and to ensure that their vehicles and aircraft remain clear of the flights.

The flight-crew use the taxi plan so as to enable them to arrive at the holding point on time.

Note: One benefit will be that the increased accuracy of aircraft movements will mean that slot allocations timings will be improved.

Whilst the aircraft is taxiing, any refinements or changes that need to be made to the departure trajectory (either by the terminal controller, the AOC or the CFMU) are negotiated between them and they are passed to the flight-crew via datalink.

5 Ground Departure (Take-off)

On arrival at the holding point the flight-crew confirm their readiness for take-off (by R/T) with the Runway Controller who, when appropriate, clears them to enter the runway and take-off (probably by R/T). The Runway controller is supported by active and passive detection systems to monitor the runway area, to guard against unauthorised runway incursions, to ensure adequate separation from other aircraft using the runway (wake vortex) so as to ensure that it is safe for the aircraft to enter the runway and take-off.

The flight-crew use their EVS and/or SVS, plus data presented on the CDTI display, from on-board and ground sources, to accurately maintain the runway centre-line and to take-off (even in zero visibility conditions). Once airborne, the flight-crew make contact with a Terminal controller who will be responsible for SA for the flight.

Notes:
1. R/T frequency changes in the aircraft and 'contact handshakes' between the aircraft and the ground as the flight moves from sector to sector (now done manually and verbally by the flight-crew) will be performed automatically, initiated by the handing-off controller via datalink and the aircraft's FMS. The flight-crew will be advised of the action and they or the controller will be able to over-ride the process.

2. Because the departure route or routing is established beforehand, there is no need for the flight-crew and controller to communicate with each other under normal conditions. Here, datalink assists both flight-crew and controller by making it possible for the passing of non time-critical messages and clearances to and from the flight to be made via datalink rather than R/T.

3. The departure route, passed to the aircraft before start-up, is one that is optimised as much as possible for the benefit of the flight (by the DMS and under the authorisation of the controller) by matching the route as closely as possible to the performance capabilities of the aircraft and the wishes of the airline. The route takes into account other departure, arrival and transit flights and the weather.

4. In addition more flexibility will be gained by the ability to dynamically restructure airspace to respond to changing traffic flows during the course of the day. as well as the weather and environmental restrictions. The primary concerns will be the same as today - to keep flights clear of hazards and to satisfy noise abatement requirements.
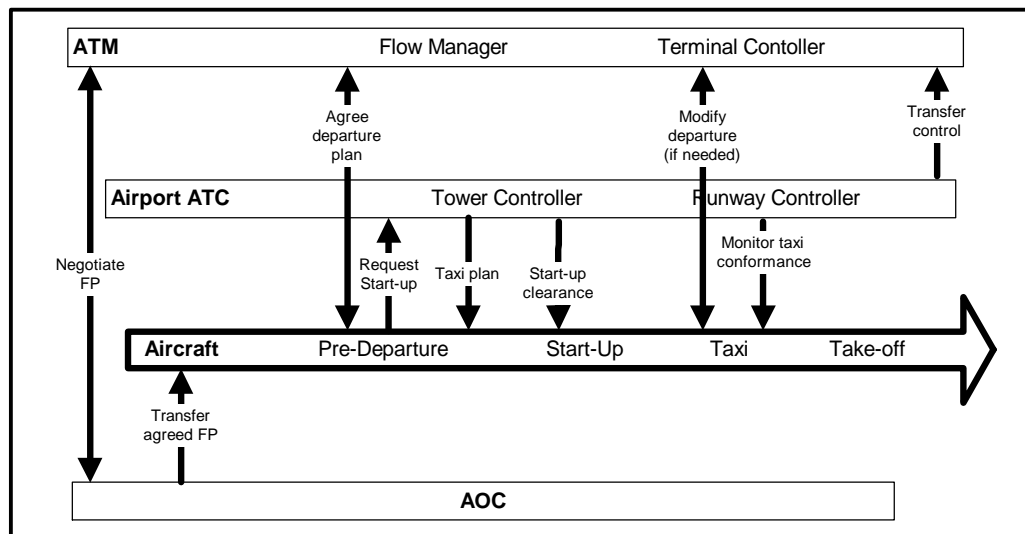
Departure Activities

6   Climb-out Phase

The flight commences its optimised departure through the TMA in which, through the planning and dynamic response capabilities of the future ATM network, stepped climbs are eliminated or considerably reduced. In addition, the minimum separation standards will be reduced (subject to wake vortex considerations), enabling greater capacity whilst still maintaining acceptable safety levels, through:

- increased aircraft navigational accuracy;

- the reliability and integrity of ground-based flight path prediction systems;

- and the ability to exchange flight intentions by datalink.

During the initial stages of the climb-out, either the flight-crew fly the aircraft manually with the aircraft's systems monitoring the flight's conformance to the approved trajectory (within set parameters), or the aircraft's systems guide the flight with the flight-crew monitoring its conformance. The flight-crew maintain their own situational awareness, assisted by ASAS which enables the flight-crew to be aware of the identity, position and short-term intentions of other flights operating in the airspace and within their area of interest.

Notes:
1. ASAS data may be gathered either by air-air data exchange between the flights or by data transmitted to the flight from the ground. In addition, the use of ACAS provides a safety-net to help prevent collisions between flights.

2. ASAS will also be used when partial delegation of responsibility for some separation functions (in-trail climb, cross/climb when clear etc.) are transferred to the flight-crew by the controller.

As the flight exits the TMA and enters the En-Route phases, control of the flight and responsibility for separation is transferred to an En-route controller, again silently and with automatic R/T frequency changes.

7   En-Route Phase

7.1   Free-Routing Flight

Our flight is operating outside the most congested airspace in Europe and outside the busiest times of day so, as the flight continues its climb, the need to remain inside a system of Structured Routes is no longer necessary. Traffic densities however, are still at a level where ATM is needed to ensure safety and to provide SA and airspace capacity.

> **Note:** Free-Routing will be possible when and where the traffic density permits and there is a economic benefit to users. It will be a development of the current practice of allowing flights to take up direct routing when possible. In the ATM network of 2015, by the development of automated support equipment in the air and on the ground, coupled to new procedures and working arrangements in ATM, Free-Routing will be used extensively by operators and will provide significant benefits in flight economy (See 5.2.3 'Free-Routing Flight Characteristics' for more detail).

The flight takes up its cleared, user-preferred trajectory. The flight is still in MAS and responsibility for SA remains with the En-Route controller, while the flight-crew's responsibility will be to ensure that the flight conforms to the agreed trajectory. Under specific circumstances however, the controller may delegate some separation tasks to the flight-crew (e.g. station-keeping, turn/change level-when-clear etc.).

As the flight progresses the flight-crew negotiate any minor deviations to their trajectory (e.g. to avoid adverse weather) with the en-route controller. Providing the flight does not deviate too far from its trajectory and returns to it relatively soon, neither the CFMU or the airline's AOC will become involved. Longer term changes (e.g. those requested by the AOC for company reasons or to avoid extensive bad weather) will need to be negotiated between the AOC, the flight-crew, the FM and the en-route controller. The precise pattern of negotiation will depend on the circumstances of the reason for the change, but will benefit from the capability to share all relevant information in real-time and the principles of CDM.

> **Note:** As the flight proceeds and control is handed-off to different sectors, it may cross one or more national boundaries. However, because the ATM network and airspace classifications of the different states are harmonised, the transition from the airspace of one State to that of another are transparent to the flight-crew.

Eventually, forecast traffic densities on the route of our flight fall to a level where Free-Flight is possible and the flight transits into FFAS.

7.2   Free-Flight Airspace

> **Note:** It had been decided during the Planning Phases that the forecast traffic flow densities and the capabilities of the flights operating in the airspace meant that in some areas, demand for capacity was not the major issue and that priority could be given to the airlines' quest for freedom and flexibility. Accordingly, during the Optimal Flow Regulation Phase, a flexible but managed allocation of Free-Flight airspace was defined for a particular area, above a certain level and for a set period of time. This information was then made available for all concerned.

The flight-crew have been using the data generated by ASAS and ACAS (although separate systems, their data will probably be displayed on the CDTI), to maintain the flight-crew's situational awareness of surrounding conditions (as described in the Climb-out Phase), but now these systems perform the role of assisting the flight-crew to assume the responsibility for airborne SA.

> **Notes:**
> 1. Through the functionality of ASAS and its conflict detection and resolution capability the flight-crew can be aware of all other traffic operating in the same airspace within its

area of interest. ASAS will gather the position and short-term intentions of other aircraft, either by air-air data exchange between the flights or by data transmitted to the flight from the ground. ASAS will use a set of 'Electronic Flight Rules' (EFR) to ensure that flights remain clear of each other and will present the flight-crew with information on the possible manoeuvres needed to resolve a problem, or on any manoeuvring constraints that need to be observed whilst in the proximity of other flights. ASAS and EFR will operate on two levels. The first will be based on an extension of the principles of the current "Rules of the Air" (but with additional information, such as knowledge of intentions, priority, manoeuvrability, emergency etc.) so as to determine what course of action a flight should take. The second will be where the flights exchange data in order to agree a common course of action between themselves. It remains the flight-crew's responsibility to choose the action they wish to take (within the regulations of EFR).

2. The AOC will oversee the flight and continue to balance the flight's schedule against that of the airline's needs and, although free to make changes, will notify any flight plan modification to ATM (having pre-notified the flight-crew) and operating on the advice received, will determine the detail of the change. When the change is determined the AOC uploads the new trajectory data to the flight by datalink and ATM distributes the new data to those affected by it.

3. Aircraft in FFAS are not totally alone. As described in the OCD 'There will be a continuing need for a ground based ATM element', and this applies in FFAS as well as MAS. The ground-based ATM element will provide a 'Safety Support' service to assist any flights which may get into difficulties, and, because of its more extensive knowledge of aircraft positions and intentions, ATM will provide a 'Safety Advisory' service to warn if specific local areas might get too congested for safe autonomous separation so that the AOCs or flight-crews can re-plan their trajectory to avoid them.

Unlike Free-routing, where the flight-crew are responsible for maintaining the agreed trajectory, they are now free to manoeuvre as they wish, subject to EFR and the need to meet the agreed exit conditions from FFAS. If the flight will not be able to achieve the exit conditions the flight-crew notify the AOC and the CFMU of their forecast exit conditions. Once again, the precise of negotiation and agreement will depend on the circumstances of the change, but will benefit from the capability to share all relevant information in real-time and from the principles of CDM.

Note: An advantage of an airborne over a ground entry is that the entry-time forecast from an airborne flight will be more accurate and reliable than that from a runway departure forecast - current research shows that an airborne aircraft can achieve a positional accuracy 20 minutes in advance of +/- 5 seconds).

Benefits: In summary, the benefits of Free-Flight for the users are that they will get freedom of movement and the ability to select the best preferred trajectory possible under the prevailing conditions and to reorder their operations in response to airline objectives.

Long-Term En-Route Activities (FFAS)
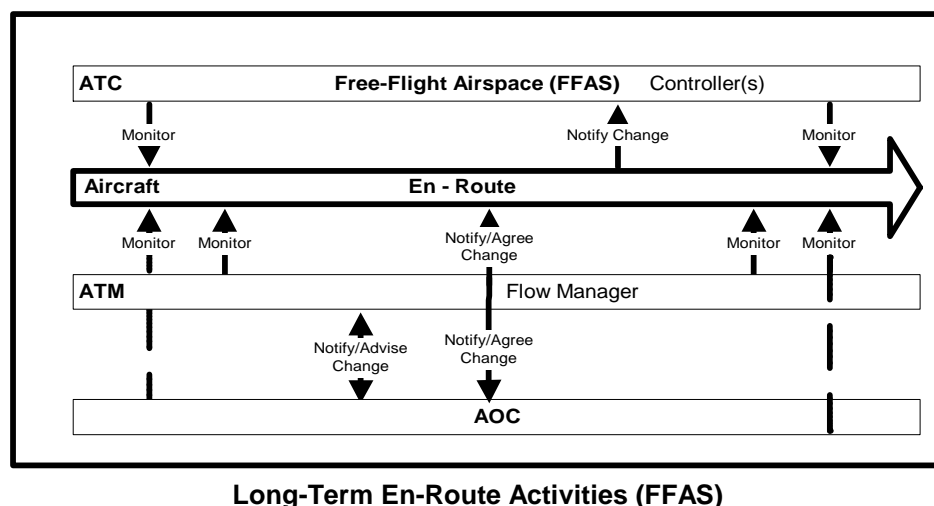
Return to Managed Airspace

As our flight nears the end of its passage in FFAS it will need to re-enter MAS, relinquish responsibility for SA, be integrated into the traffic flows towards the destination airport and into the airport landing sequence (see Appendix 2 for descriptions of flight in MAS).

8   Descent and Approach Phase

At one point, as the flight approaches its destination the flight-crew start to negotiate their arrival trajectory with a Terminal controller. The controller will use the AMS, which has been regularly updated on the progress of the flight, to assess its effect on the arrival sequence, if any, and to determine any constraints that may need to be applied. Depending on the traffic density the constraints can range from:

- designating a set trajectory for the flight to follow;

- passing details of the planned and real-time approach/departures of other flights, but otherwise leaving trajectory selection to the flight (the on-board systems will have all permanent and temporary airspace restrictions data);

- agreeing a time and level for the flight to arrive at the initial point for final approach.

> **Note:** The methods of control and situational awareness for the flight-crew are the same as those in the Departure phase. However, a principal aim for arrivals management where traffic density is not a problem is to grant as much freedom of operation as possible to the user. If the traffic level is low therefore, there is no need to restrict aircraft trajectories except to ensure separation from other traffic, reserved airspace or for environmental concerns.

Depending on the circumstances, the flight-crew either receive data up-linked from the AMS or down-link their own trajectory to the AMS and controller.

When appropriate, the flight begins descent in the initial stage of the approach. As in the climb-out, the flight-crew monitor and confirm that the aircraft's FMS is guiding the flight in conformance with its planned trajectory, is assisted by ASAS to maintain their situational awareness and ACAS as a safety-net.

> **Note:** Once an arrival time for the flight has been established, the Tower controller, notified of the flight's arrival, uses the SMS (which is linked to the AMS and En-route system) to determine the optimum taxi route for the aircraft to its gate. When the controller has reviewed and authorised the taxi plan the data is up-linked to the flight.

As the flight enters the TMA the flight-crew can see other flights in the airspace, either visually or via ASAS data on the CDTI, and monitor their separation. If traffic levels are very low, the flight can operate in Free-Flight mode, with the flight-crew being delegated responsibility for SA. At higher traffic levels a Terminal Controller would be responsible for SA but could, as described before, delegate to the flight-crew some responsibility to provide self-separation from other traffic.

9   Ground Movement Arrival Phase

The flight completes its approach and landing on the runway. The Tower controller, using SMS, confirms or modifies the taxi plan for the flight. Any changes are uploaded to the flight, again by datalink. Taxi from the runway to the gate is the same process as that described for the ground departure phase.

10   Post-Flight Phase

Our flight has reached its gate, the engines spooled down, passengers and flight-crew departed and the ground services now ready the aircraft for its next flight. But that is not the end of the involvement of the future ATM network. Firstly, the data from the flight are collated with all other data concerning it (e.g. from the AOC, Flow Management, ATC) in order to be able to provide a comprehensive and authoritative source of data on all completed flights. This data will be

accessed by the States, service providers and airspace users for a number of reasons. The principal aims are to:

- provide an integrated, consistent, accurate and efficient navigation charging system;

- confirm that any Quality Service Plans were satisfactorily achieved, or to identify any shortfalls or problems;

- analyse flight and performance data in order to improve the operation of the ATM network in the future, with due regard to the protection of confidential data.

Appendix 2   Commercial IFR Flight in Managed Airspace

1   Scenario

The Flight is:

- an IFR Commercial flight, belonging to a large airline;
- equipped with FMS, 4-D flight capability, EVS, SVS, ASAS and datalink;
- operating entirely in MAS between two major airports in the busiest airspace;
- managed by an AOC.

The Airports are:

- major, high complexity airports with optimised taxi-routes;
- equipped with SMS, AMS and DMS;
- equipped with datalink;
- capable of all-weather operations;
- in a complex, multiple-airport TMA.

2   Pre-Flight Phase

See Appendix 1 for a description of the Pre-flight phase activities.

3   Ground Departure

See Appendix 1 for a description of the Ground Departure phase activities However, at a busy airport additional measures will be needed to ensure efficient throughput. Such measures will consist of taxiway holding points to keep a reserve pool of aircraft so as to 'feed' the runway or to hold them on the ground until it is time to take-off in order to meet a confirmed landing time at their destination airport, although the users will still be free to exercise their own judgement and elect when to take-off.

4   Climb-out Phase

See Appendix 1 for a description on the Climb-out phase activities.

However, the TMA around the Departure airport in this scenario is very complex, serving a number of airports and the interactions of level, climbing and descending flows of transiting, departing and arriving flights in the same airspace have to be regulated. In these conditions, the needs for safety and efficiency in maximising capacity and throughput will take priority over individual flight optimisation.

5   En-Route Phase

Our flight is operating in the most congested airspace in Europe and at the busiest time of day, so the entire flight will be conducted inside established routes (Structured Routes) which will be similar to today's airways. A number of improvements however, over today's airways flight operations will be achieved in the ATM network of 2015.

Notes:

1. The rigid route structures of today, that impose permanent constraints on flight operations, will have been improved by optimising them for flight economy and making them dynamically adjustable in response to the differing capacity demands and traffic flow variations during the course of the day. The need to ensure adequate capacity and equitability amongst users in areas of high traffic density means however, that there will sometimes be constraints on the freedom of flights to optimise their individual trajectories.

2. The procedures for control of flights will be improved. Flights will still be controlled by Controllers but will be assisted by automated support systems to detect and resolve short-term conflicts and in the monitoring of a flight's conformance to its agreed trajectory. Controllers' workload will also be eased by the involvement of MSPs, in areas where the density of traffic makes their use necessary. MSPs will use computer support tools to oversee a number of sectors and be responsible for the resolution of medium-term traffic problems, to manage and balance the complexity of traffic flows and so ease the controllers' workload.

The flight finishes its climb-out and levels off at its requested flight level, with the flight-crew continuing to monitor the flight's conformance to the flight plan and maintaining situational awareness.

The flight-crew's responsibility will be to ensure that the flight conforms to the agreed trajectory. Under limited specific circumstances the flight-crew may be delegated the responsibility for maintaining separation from other aircraft flights.

The AOC will continue to oversee the flight and the airspace. If, for example, the early closure of SUA gave the opportunity for benefit to the flight or airline, the AOC would, depending on whether it would be a change in the long or short-term, either:

- request and negotiate a change with an FM (after pre-warning the flight-crew) and then up-link the new Flight Plan details, or;

- pass the details to the flight-crew for them to negotiate a revised route with the MSP and/or the controller.

En-Route Activities (MAS)
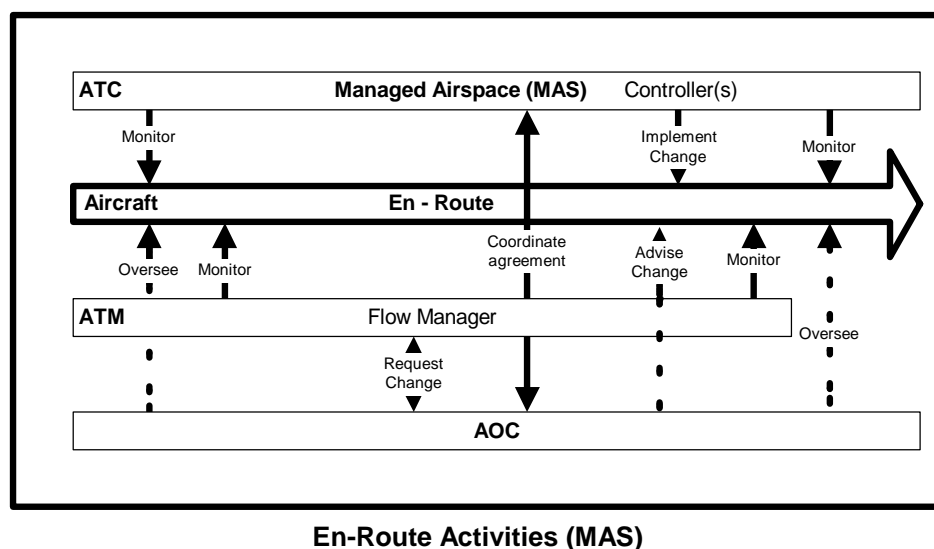
6   Descent and Approach Phase

See Appendix 1 for initial details on the Approach and Descent phase. However, because the destination is a busy, major and high complexity airport the options on freedom of choice for

approach are limited. The controller therefore, using data on the flight's performance capabilities and preferences contained in the flight plan and on the known position and intentions of the flight, and on all other traffic, uses the AMS to formulate a descent and approach trajectory for the flight, to enable it to achieve its planned landing time.

This proposed 4-D trajectory is passed to the flight by datalink and the flight-crew either agree it or negotiate alternatives until a trajectory is agreed.

Note: The methods of control and situational awareness for the flight-crew are the same as those in the Departure phase. However, a principal aim at a busy airport at peak traffic density periods is to fill the gaps in what could be an irregular arrival sequence and to avoid the bunching of flights. This can be achieved by funnelling flights through short-duration holds to smooth out the irregularities and keep delays to a minimum. Flights in the TMA may also have speed constraints imposed and in extreme circumstances may have to enter holding patterns. If the runway utilisation problem is not as pressing, there may still be the need to modify the flight arrival trajectory by the use of route adjustment to give or make up time to allow for aircraft with different approach speeds.

When appropriate, the flight begins descent in the initial stage of the approach, as described in Appendix 1 Descent and Approach phase.

7 Ground Movement Arrival Phase

See Appendix 1 for a description of Ground Movement Arrival Phase activities.

Approach Activities
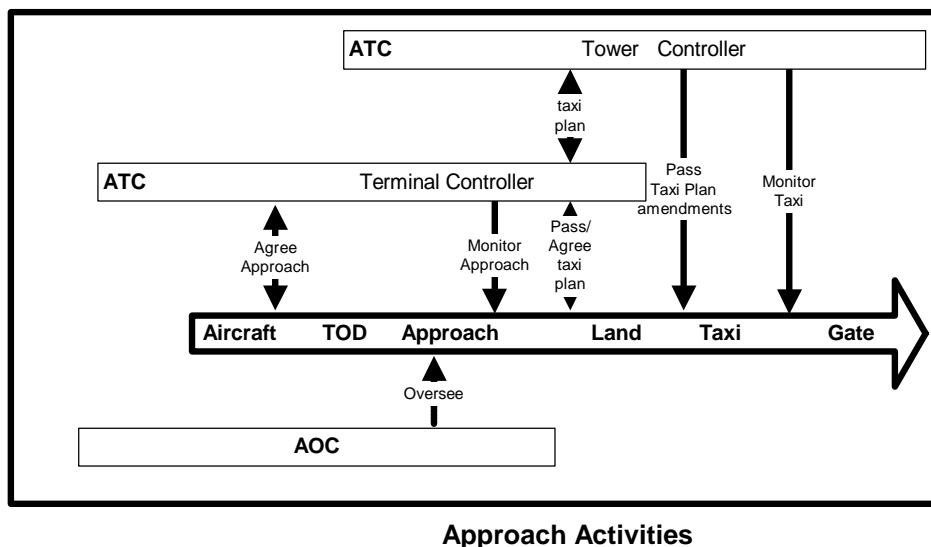
8 Post-Flight Phase

- See Appendix 1 for a description of activities in the Post-Flight phase.

LEFT INTENTIONALLY BLANK

Appendix 3   General Aviation's Viewpoint

1   Introduction

General Aviation (GA) flights are performed by a wide variety of aircraft with many different levels of capability and types of operations. Rather than provide a single scenario with many variation notes, the material for this Appendix is presented as a set of the principal elements and characteristics of GA in general and of three types of operations: Business, Aerial Work and Sports/Recreation GA.

2   General

2.1   Contributions

GA contributes to European economies by providing:

- service capabilities outside those provided by air carriers;

- jobs, goods and services (including the production of GA aircraft and avionics products) and flight training, aircraft leasing and maintenance, plus insurance and finance services.

2.2   Concerns

The overall concerns of GA are that:

- increasing regulations, restrictions and additional requirements will have a negative impact on their flexibility;

- that their access to airspace will be further restricted;

- they will be required to pay for services that they do not use, need, or benefit from;

- the strategic planning process should not prevent their ability to operate flights at short notice (e.g. notification one hour in advance);

- UMAS is not sufficiently safeguarded for use by sports and recreational GA.

The prime requirements are that GA not lose any of the flexibility that it has now and that their freedom to access airspace at no additional, or at worst minimal, cost will be preserved.

2.3   Benefits

The benefits to GA will be:

- firstly, the more efficient use of airspace, which will result in an overall reduction of MAS in most areas, and via dynamic airspace re-structuring will open up airspace at times when the traffic density is lower, even in the busiest airspace;

- secondly, that improvements in slot-allocation times mean that more slots will be available to GA at non-saturated airports.

There will also be benefits of increased safety due to:

- better decision-making enabled by open and timely access to accurate Meteorological, AIS and ATFM information provided by several commercial or association information providers and airspace structure information provided by ATM;

- advances in technology and training to reduce the problem of human-induced accidents (the weakest link in GA air safety);

- the availability and affordability of Flight simulators.

Other benefits will include:

- the ability to conduct flight operations in airspace, harmonised throughout Europe to the same standards and procedures;

- more open access to airspace relinquished by ATM when IFR traffic levels permit;

- increased efficiency and reduction in costs for business and corporate GA by the availability of more, better and timely information, enabling routes to be more direct, particularly through Terminal and SUA.

3 Business Flight Operations

Apart from those business operators that have full facilities and can be considered in the same light as commercial flight operators, the principal factors that define Business operations are conducted by flights that are:

- often undertaken at short notice with potential problems in accessing airspace and obtaining landing or take-off slots at busy airports;

- more frequently diverted or re-routed, and at short notice;

- less likely to be as fully-equipped as commercial airlines, caused either by cost constraints or below size for regulated equipment;

- more likely to be operating from uncontrolled airfields;

- unlikely to be supported by a dedicated AOC for flight planning or flight amendments;

- likely to be linked to ATM via general telematics services.

3.1 Pre-Flight Phase

The future ATM network, under the principles of IM, will make available the data that will enable GA operators to collect the ATM information that they will need to plan their flight (MAS, Route and SUA dimensions and timings, Centre capacity forecasts, airport arrival and slot departure slot availabilities etc.). In addition, data will also be available from airports, public services, private associations and commercial enterprises (weather now-casts and forecasts, flight planning services etc.) either through the ATN, or through public or private links. With the development of flight planning packages and services, GA operators will be able to decide their flight plan requirements quickly and easily.

Access to the CFMU and an FM to negotiate and agree flight plans will be available over automated links, thus enabling a fast response, negotiation and agreement process.

3.2 Departure Phase

Flights not equipped with datalink capability will remain reliant on voice R/T for the exchange of all taxi and runway clearances. The ability of the flights to operate in adverse weather condition, if not equipped with EVS/SVS will be adversely affected.

3.3 Climb-out

For aircraft that can fly 3-D but cannot negotiate and fly a 4-D trajectory, the controller, using the DMS, will be able to provide a departure trajectory that matches the notified performance capability of the aircraft as closely as possible, subject to the need to ensure that the trajectory will be planned to remain clear of other traffic and to satisfy noise and other environmental constraints. Also, for a flight without datalink or automated R/T frequency transfer capability, all clearances and messages will be via R/T.

3.4 En-Route

In busy and congested airspace, a significant amount of flight will be via structured routes. There will be the possibility of direct routing, subject to sector workload, and limited opportunities to perform real-time route optimisation. In less-busy airspace there will be more freedom to manoeuvre and to optimise the flight trajectory. Because of the greater knowledge of conditions on the route of flight, if circumstances arise that would permit the route to be optimised (e.g. by the unexpected early closure of SUA), ATM would advise the flights and offer re-routing.

3.5 Arrival

As for departures, for aircraft that can fly 3-D but cannot negotiate and fly a 4-D trajectory, the controller, using the DMS, will be able to provide an arrival trajectory that matches the notified performance capability of the aircraft as closely as possible, subject to the need to ensure that the trajectory will be planned to remain clear of other traffic and to satisfy noise and other environmental constraints. Also, for a flight without datalink or automated R/T frequency transfer capability, all clearances and messages will be via R/T.

4 Aerial Work Operations

GA Aerial Work operations interact with the ATM network as flights whose operations impact on airspace reservations and which are characterised by the frequent need for reserved airspace to protect their operations and to transit or operate in MAS. The future ATM network, through IM, will be capable of reacting more quickly in the allocation of special reservations of MAS to suit the particular requests of Aerial Work operators. In addition it may be possible to delegate some separation responsibilities so as to enable suitably-equipped aircraft to operate with more flexibility and efficiency.

4.1 Pre-Flight:

In addition to the Pre-Flight planning facilities for GA Business and Aerial Work, flights may require facilities for the reservation of MAS during their operations. The IM facilities in the ATM network will enable these activities to be more easily carried out, reducing the amount of time needed for booking airspace reservations.

4.2 Airborne

The IM facilities in the ATM network will enable more accurate and up-to-date information on the usage and release or reserved airspace, reducing the amount of time it is unavailable to IFR traffic and conversely in the release of MAS for Aerial Work operations.

5 Recreation/Sports Operations

Recreation/Sports operations interact with the ATM network as flights which remain largely outside of the ATM network and are generally characterised by operations from uncontrolled airports and in UMAS, but which may need clearances to cross or fly in MAS and FFAS. In the same way as for Aerial Work operations, ATM will be able to react more efficiently to Recreations/Sports requests for airspace to be made available for specific reasons/events . Advances in the ability to select data from a set of service providers (who may or may not charge a fee), in addition to airspace data provided by ATM, will help to enhance operations and maintain or improve safety levels.

Principal characteristics of non-powered and powered Recreation/Sports flights are:

5.1 Non-powered

Non-powered flights are characterised by local or cross-country operations. The principal data needed in both cases, which are: airspace structures and accurate and detailed data on forecast thermal conditions, with particular emphasis on extreme wind and thunderstorms, will be available from ATM and from a number of free or charging service providers.

Local Operations:

The upper level is dependent on the particular weather conditions. Under the future ATM network, applications to operate in MAS above the launch site will be more readily assessable and controllable.

Cross-Country Operations:

Flights are normally planned to be performed in VFR conditions but may need to pass through MAS. A flight's track, level and intentions are almost entirely subject to the dictates of the weather conditions and there is therefore, a degree of uncertainty in predicting its position. The ATM network will, via IM be able to provide data on MAS dimensions. However, to operate safely in MAS, a flight will need to be able to communicate its identity, position and general intentions to ATM.

5.2 Powered Flights

Some powered flights will operate completely in UMAS and will need no information from ATM other than the dimensions and timings of MAS so that they can remain clear. Others may want to provide a level of conspicuity to ATM and to file a general flight plan and others will want to penetrate MAS, either for crossing purposes or to go to a controlled airport. Here, as well, advances in the ability to select data from a set of service providers (who may or may not charge a fee), in addition to airspace data provided by ATM, will help to enhance operations and maintain or improve safety levels.

Operations in MAS

Operations in MAS will remain essentially the same with the provision of Special VFR corridors for GA flights. If a flight wishes to fly in MAS it will need to be able to communicate its identity, position and intentions to ATM.

Appendix 4   Military Aviation's Viewpoint

1   Introduction

Military aviation has a vital role to play in the security of Europe. To this end, military aircraft need the freedom to operate in any of its airspace. Moreover, in times of crisis and war it may be necessary to prohibit the civil use of specified areas of airspace and to ensure that military operations have priority over all other airspace users.

In order to carry out their operational tasks, military aircraft often have special requirements for airspace (e.g. low-level flying, in-flight refuelling and air-to-air combat training). Furthermore, airspace reservations are also required for non flight-related activities (e.g. the protection of areas of national interest, gunnery, missile firing etc.).

Military aviation operates a wide range of aircraft types, from large transport aircraft, through bombers, fighters and training aircraft, to helicopters and unmanned aerial vehicles. These aircraft are either:

- equipped to civil standards and can operate in the same way as civil GAT flights (in particular, transport aircraft operations may, in general, be considered as similar to those of commercial airlines);

- operating as GAT, but which are not equipped to civil standards (in particular, fighters and training aircraft) because of the limited space available for equipment to enable them to conform fully to civil standards;

- operating as OAT flights transiting MAS and/or FFAS;

- operating exclusively in UMAS or in SUA.

2   Military Aviation Concerns

The principal concerns of military aviation are:

- the need to conduct day-to-day operations in order to ensure the ability of the armed forces to meet the defence needs, as specified by National governments;

- ensuring the ability to maintain National security and that National sovereignty is not compromised;

- maintenance of the ability to detect and identify all traffic in the airspace through non-collaboratory means;

- to preserve the right of free movement of military aircraft within any airspace;

- the availability of restricted airspace for defence needs;

- the availability of Temporary Segregated Airspace (TSA) as required;

- the need for 'special handling' considerations in scheduling systems, particularly for priority flights and those with time-critical missions or which have limited fuel loads and therefore, flight duration restrictions;

- the interoperability of the future ATM network with defence systems, including NATO Air Command and Control System (ACCS);

- the confidentiality and reliability of information within the ATM network, including the safeguards for the restriction of access to military data;

- the financial impact of the requirements for airborne and ground facilities that will be created in the future ATM network;

- the potential introduction of user charges to military flights by privatised service providers.

3   Airspace Reservation Planning

The uncertainties affecting some military long-term planning prevent the precise prediction of all airspace usage in advance of the day of operations. In the future ATM network the military requirements for the reservation of airspace will be determined, incorporated and revised, in co-operation with other organisations, during the Strategic Flow Scheduling and Optimal Flow Regulation Phases. During the Tactical Flow Planning Phase and on the day of operations, the military, through Airspace Management Cells, will notify civil organisations of the dimensions and times of operation of their actual airspace usage requirements. The use of IM will reduce the time between the release of airspace by the military and time when it can be used by other air traffic.

4   OAT Operations

Although each nation has its own rules for the management and handling of OAT flights it is essential that ATM be made aware of all OAT flights to ensure the safe conduct of flight operations between OAT and GAT flights when operating in the same airspace. It should be noted that the ATS for OAT flights may be provided by military ATC, civil ATC or Air Defence. OAT operations will take place in all ECAC airspace (UMAS, MAS and FFAS). In general, there are three types of operation:

Air Defence and Search and Rescue

The military have responsibility for the securing and policing of a State's airspace, and military aircraft need to react at short notice to perceived or possible threats. The military also assist in Search and Rescue operations. The priorities of these missions are such that they take precedence over GAT operations.

Training Missions

Military aircrew have a requirement to train in order to maintain the professional standards required to conduct operations as ordered by their governments. This training includes such tasks as low altitude flying, in-flight refuelling, weapons practice and air combat training.

Exercises

As well as for individual training it is also necessary to reserve larger amounts of airspace for air, naval, ground or combined services exercises.

4.1   OAT Flight Planning

Air Defence and Search and Rescue

These mission can occur at very short notice, depending on the perceived severity of the threat or on the degree of urgency, and cannot normally be planned much in advance. Consequently, flight planning is a real-time activity in which the future ATM network will need to be able to respond quickly and effectively to notification by the military in order to ensure that the operations are not hindered by civil activities.

Training Missions:

Training missions are normally planned in advance. However, some missions necessitate good meteorological conditions and have to be cancelled if there are bad weather conditions. Consequently, if the weather conditions do not permit Visual Meteorological Conditions (VMC) operations, it may be necessary on the day of the mission for the aircrew to plan an alternative mission or to fly the planned mission in IFR, possibly as GAT. In the same way, the weather conditions in airspace reserved through the Airspace Management Cell may not be as predicted and be unsuitable for the planned mission and can, therefore, lead to the cancellation of the reservation and the release of the airspace for the benefit of other airspace users. These changes in mission profile may lead to ATM receiving military flight plans, at relatively short notice.

Exercises:

Major national and international exercises are planned well in advance. The dates, airspace reservations and routes are all negotiated with the relevant civil authorities, taking into account busy days and special events. Smaller, minor exercises are negotiated with civil authorities on a case by case basis, if required. In all cases, airspace users are informed of the exercise details by NOTAM. However, exercises, particularly ones involving aircraft from a number of different nations, may well result in large numbers of aircraft routing to/from a particular destination, often as GAT, and requiring special handling to ensure that operational timings are achieved.

5 GAT Operations

Military flights operating as GAT will comply with the corresponding rules and procedures to the maximum extent possible. Aircraft which are required to operate as GAT on a regular basis, e.g. transport aircraft, will generally be equipped to the appropriate civil standard. However, other aircraft particularly combat and training aircraft, which are required to operate as GAT only on an infrequent basis, may not be equipped to the same standard. These aircraft are limited in the amount of space available for fitting equipment to satisfy civil requirements, since priority must be given to their primary roles. Some equipment, although certified only by military authorities, will meet the performance requirements for operating as GAT whilst not being fully compliant. It is recognised that improvements in technology, by reducing the size of airborne equipment, could have a positive effect on the possibilities to fit combat and training aircraft to the required standard. ATM procedures should allow these aircraft full and un-delayed access to airspace without any additional requirements with respect to equipment fit. Special procedures have to be developed in an ECAC-wide harmonised way. Due account must be given to the high performance characteristics of combat aircraft.

Since military aircraft need a diplomatic clearance in order to operate in another country's sovereign airspace, route deviations leading military aircraft through 'un-cleared' airspace are prohibited.

5.1 GAT Flight Planning

Flight planning will normally be similar to that for civil operations, but flight plans may be submitted, and will have to be accommodated, at very short notice. Differences from the standard required airborne equipment fit will be clearly stated in the flight plan. The prevailing procedures will be applied to a flight that requires priority handling or if security issues occur.

5.2 GAT Flights

GAT flights by military aircraft will be conducted in UMAS, MAS and FFAS. Military transport aircraft will behave as normal civil air traffic. Other military aircraft will operate with some or all of the following constraints:

- most aircraft will not be equipped for the conduct of autonomous operations in FFAS;

- the conduct of 4-D trajectory operations will not be possible for most aircraft;

- aircraft will not be equipped with on-board Surface Movement Guidance and Control Systems;

- there will be less capability for datalink exchange (fewer parameters);

- most aircraft will not be equipped with a Traffic Alert and Collision Avoidance System (TCAS) equipment, but will have Mode S transponders and will therefore, be detectable by aircraft that are equipped with TCAS;

- height-keeping ability may be less precise;

- if not fully equipped to civil standards, they will navigate en-route by other means such as Inertial Navigation Systems, Tactical Air Navigation System and Global Positioning System.

6   Systems Interoperability and Data Exchange

With the development of the systems and procedures that will be implemented by the use of better technological solutions than those available today, the interoperability between civil and military systems will become an increasingly important factor in future operations, especially in the light of the introduction of the NATO ACCS and the different National procedures for controlling military OAT flights.

There will be increased communication and data exchange between the civil and military at all levels of ATM, from the Strategic Planning Phase through to the safe conduct of flight operations by different types of air traffic on the day of operations. This will be enabled by automated support tools for both civil and military use. This can be achieved through the use of a shared infrastructure or through the use of datalink between centres which are not colocated.

As well as notification by the military of the establishment, closure or suspension of TSA, there will be a need for exchange of information between military and civil systems in order to collect data for any post-flight review or performance review activities.

7   Security

The future ATM network will accommodate the co-existence of civil and military aircraft operations, and for the collation and notification of information about flights for Defence purposes. Effective co-ordination between civil and military systems in the exchange of data (verbal and automated) in which the civil ATM network will ensure that any data deemed 'sensitive' by the military (e.g. flight data on specific OAT flights) is only made available to those who are eligible to receive it and that such data is fully protected from inadvertent dissemination or malicious acquisition.

Appendix 5   Planning Viewpoint

1   Planning Overview

European airspace is a complex environment in which the individual and co-ordinated actions of thousands of people, systems and aircraft form a pattern of events at all levels and determine how well and how smoothly the future ATM can function, subject of course to the weather conditions which, if they are bad enough, can disrupt any plan.

Planning will be a seasonal, CDM process in which the collection, collation and analysis of data to produce an accurate picture of the demands and constraints that will affect European airspace will begin two years or more before the day of operations.

A series of optimised airspace structure and forecast traffic models in the form of Operations Plans for the entire usable European airspace will be created, in which the allocation of European airspace will be balanced between the needs of Commercial, General and Military aviation and other users. The airspace will be assigned as MAS (in which the future ATM network will provide the majority of its services), FFAS and UMAS. These planning processes will be divided into 3 major phases:

- Strategic Flow Scheduling; involving the long-term activities to produce a co-ordinated Strategic Plan of demand and capacity one year in advance;

- Optimal Flow Regulation; involving the modification of the co-ordinated Strategic Plan from one year in advance to one day before;

- Tactical Flow Planning; involving final modifications to the plan within 24 hours of the time of operation of the flight.

The volume and complexity of data to be processed so as to produce the Operations Plans will require the support of advanced Fast-Time Simulation (FTS) systems, developing plans at each level; the results of which will be available to all eligible parties and will contribute to a transparent negotiation and agreement environment.

IM will be the single most important concept around which the activity of the ATM planning phases will be built. A system (or systems), consisting of a network of databases, connected in a collaborative, interactive and pro-active framework of computing installations and suites of programs will provide the medium in which the different levels of planning will be performed.

Data on planned flights, the weather, ATM capacities and capabilities will come from many sources in and beyond Europe and will need to be collected, collated and analysed to provide the refined data needed to build up the simulation layers supporting each planning phase. The simulations will provide models of the total European airspace as sets of regional, interconnected plans that will be capable of determining the demand and capacity of ATM. The simulation will then be able to determine the effects of any proposed changes on the safety, capacity and efficiency of the system and then to assist the planners in modifying the plans to resolve any problems. Data on the simulation modules will be shared with all those eligible to have access, presented in the format most suited to their requirements.

2 Strategic Flow Scheduling Phase

Airlines and other users will have been planning their operations for some time in advance of 2015, but the Strategic Flow Scheduling Phase in the future ATM network will begin sometime in 2012 or 2013. At this time very little information is known about the summer of 2015, but there will be some data on:

- demand from scheduled and non-scheduled flights;
- Airspace availability (allocation of airspace to the States, Military aviation, Recreational and Sports users);
- ATM resource availability (capabilities and capacity declarations) and the impact of operational changes (new procedures, new standards);
- ATM and Airport facilities availability (new equipment and new or larger airports):
- approximate estimates on the weather conditions for the season;
- historical data on seasonal, weekly and daily traffic flows;
- finally, estimations of likely business and other non-forecast airspace users demands.

The use of this data by FTS will result in the production of sets of plans that will optimise the dimensions of the airspace regimes to satisfy the forecast traffic flows.

Benefits: The planning processes will be improved, developing from a tactical/reactive system to one which will be strategic/proactive in which predictability is improved and which will allow the maximum possible flexibility and economy of operations for the user in normal conditions. Users regimes and route structures will be established to best suit the traffic flows and to assist traffic separation by the creation of discrete routes which will be re-configurable in line with the different demands on airspace at different times of the day and night. In high traffic density, ATM will establish airspace regimes and route structures to maintain or improve safety levels, capacity and efficiency in the use of airspace and of runways.

3 Optimal Flow Regulation Phase

During 2014, data received from all service providers and users (confirmations, modifications, cancellations and additions) that could affect the plan are received, analysed and incorporated. The plans developed in the Strategic Flow Scheduling Phase are progressively refined and expanded, taking into account user preferences for flexibility, punctuality or service quality requirements (different users are interested in using the data in different ways so, although the data is the same, it is extractable in different formats). The plans provide a framework that:

- gives a good forecast of the traffic demand and the users' capabilities (equipage levels);
- resolves conflicts of interest between those parties and user groups that plan their activities up to years in advance, whilst also estimating the reserve capacity and airspace needed for those airspace users who, due to the tactical nature of their operations, cannot plan well in advance;
- sets the rules and parameters which broadly outline everyone's access to airspace, routes and airports;
- provides estimates on the reserve capacity that may be needed for each day's traffic situation.

The final, publishable DOP is developed into regional, hour-by-hour, scenarios that are finalised and promulgated approximately 18 hours before midnight of the day of operation. The DOPs contain, for example (not an exhaustive list), known:

- flight plans;
- airspace regimes and reservations plans, route configuration plans;
- service provider serviceabilities and capacities.

4 Tactical Flow Planning Phase

The time from 24 hours before the start of the DOP marks when real-time information, such as the weather forecasts, traffic demand and airspace reservations starts to affect it.

FMs will use this information on a continuous basis to:

- predict en-route and terminal capacity and traffic densities for the remainder of the day;

- update the hour-by-hour forecast of local capacity bottlenecks throughout the region(s);

- assess the impact on the complete flight trajectory of individual flights (i.e. from gate-to-gate).

The FMs choice of action, if intervention is necessary, will be chosen from the following strategies:

- prevention of demand-capacity imbalances (e.g. re-optimisation of traffic);

- modification of the en-route airspace regimes and route structures if an overall benefit for all airspace users can be achieved;

- depending on the severity and duration of any overload (e.g. airport unavailability, severe weather etc.), the;

  1. notification to airspace users of where and when they will encounter delays of limited duration;

  2. application of ground holding strategies, i.e. manage departure slot allocation;

  3. organisation of crisis management, i.e. equitable re-partition of available capacity in cases where significant numbers of flights have to be cancelled, diverted or re-routed.

Tactical operations planning is a rolling process, in which the planning horizon is extended by 24 hours each time a new DOP is promulgated. The new 24-hour period is 'appended' to the remainder of the current day, and subsequent planning occurs in a seamless way on the remainder of the time period.
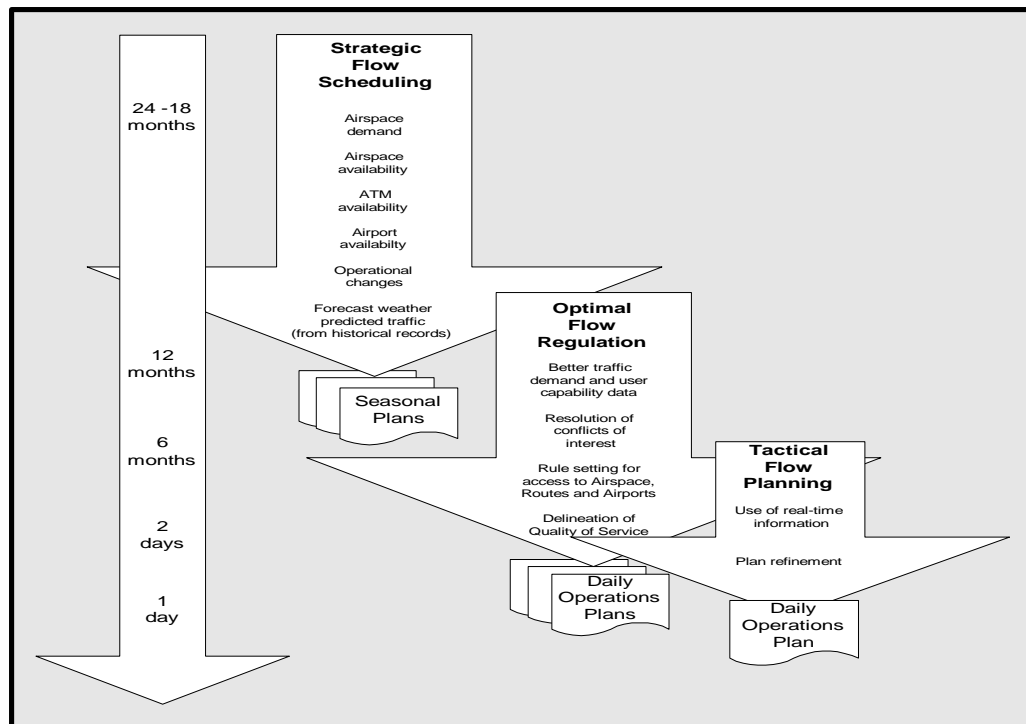
Planning Phases

PAGE LEFT INTENTIONALLY BLANK

Appendix 6   The Airline Operations' Cell Viewpoint

1   Purpose and Role

Airline Operations Cells (AOC)s are integral elements in representing the interests of the airline and will be the major interface between them, the flight-crew and the future ATM network in determining the optimum profiles for the airline's flights.

2   Pre-Flight

Some time before the start of a flight an AOC, tasked with implementing the airline's objectives, starts planning for the flight (originally scheduled up to about a year before) to work out the best flight plan. This can change from hour-to-hour or even minute-to-minute because the changing preferences or priorities for an individual aircraft have to be balanced against those of the rest of the airline fleet.

In the future ATM network the AOC will have greater opportunities to meet the airlines objectives, working closely with FMs at the CFMU in a new balance of responsibilities and functions in the conduct of a flight. This will be effectively a partnership in sharing information and decisions to optimise flight operations, to reduce cost and delay and to maintain safety and equitability. Two features in the future ATM network that will benefit this partnership are IM and CDM.

> **IM**, as well being able to gather data on the airline's operations, either through ATN or its own data network, gives the AOC access to the same 'picture' of the air traffic situation over Europe as other airspace users and service providers (subject to the confidentiality of some data). This means that the negotiation process with the CFMU is a lot easier since the AOC can have more complete knowledge of the current and forecast traffic situation and can take this into consideration in developing the initial flight plan.

> **CDM** uses the improved exchange of data between users and service providers to improve the decision-making process. It gives the responsibility for making user operational decisions to the users, within sets of established procedures, where the AOC focuses on determining their own priorities and retaining operational control over individual flights, and the CFMU, whilst co-operating and assisting in this, focuses on safety and equity among users. This principle is applied not just to the AOC - CFMU relationship but also to all participants.

The AOC examines the requirements for the flight and of the current and predicted air situation, such as the weather, en-route capacity, airport capacity and airspace structures, so as to select the optimum flight plan. This now has to be agreed with an FM and so it is transmitted to the CFMU for negotiation and approval.

An FM examines the requested flight plan to see if it is acceptable or if there are any potential resource, capacity or congestion problems. If there are problems, the FM will identify cost-effective alternatives in co-operation with the AOC, giving the AOC the freedom to choose the most optimum solution for the flight. If however, safety levels or equitability might be compromised, the FM will be the final arbiter in determining the flight plan.

Once the details of the plan are agreed (e.g. either by changes to the flight plan or to the resource and capacity levels of en-route Centres) the plan will be distributed automatically to all interested parties (e.g. Centres, destination airport, military etc.).

3   Flight Operations

Until flights are active, the AOC's role is the primary one in flight planning for deciding where flights will be and when they will be there. Once a flight is on the move however, (on the Airport or in the air) the balance and influence of AOCs will depend on the particular circumstances concerning each flight (as described in the following paragraphs).

3.1   Ground Movement

During the Ground Movement Departure Phase the AOC's influence will be limited to longer-term decisions or to short-term reaction to a sudden problem. IM, in the future ATM network will enable data affecting the flight to be much more up-to-date. If a problem occurred at the destination airport to affect its allocation of arrival slots, the information on the delay (cause, effect, likely probable duration) will be available almost instantly via IM.

The AOC, ATM and perhaps the flight-crew will be able to receive the information as 'pushed' data (data which when it changes, if previously selected by the recipient, can be displayed automatically, without the need to call it up). The decisions on what to do and which flights to hold would be worked out (in which the AOCs and ATM would collaborate to determine which flights to delay).

3.2   In Managed Airspace

Structured Route Flight

When traffic density is high, flights will have to operate inside a network of structured routes, optimised to satisfy the overall traffic flow demand for capacity and for safety (Structured Route flight).

AOC's Role in MAS Structured Route Flight

The AOC's involvement in the progress of the flight once it is in Structured Route flight will be limited. This is because the tightly-coupled co-ordination required between Planners and Controllers in the long, medium and short term in order to satisfy capacity and safety needs for the benefit of all users in high-density routes will have to take priority over individual flight requirements.

At other times of day, when the traffic characteristics are different, the airspace, routes, and sector and Centre boundaries that had been optimised to accommodate the flow during peak traffic periods, will be restructured in accordance with the new demand, (these restructuring plans were determined in the Planning phases). There will also be periods when the natural ebb and flow of traffic means that there will be a transient lessening of traffic density. Although the route structure will remain in place, the AOCs will have more opportunity at these times to agree changes to the arrival sequence among their own fleet of aircraft, although the final decision will always rest with ATM.

Free-Routing

In some airspace and at some times, the capacity demands that force the need to create route structures in MAS (even though they are dynamically alterable) will no longer apply. Under these conditions MAS can accommodate user-preferred trajectory operations in which flights choose their own trajectories whilst remaining under ground control for SA: this is Free-Routing.

AOC's role in Free-Routing

The AOC is continually seeking to satisfy the airline's objectives. As actual weather conditions, traffic flow and an airline operations and preferences vary in real-time so the optimised profile for a flight can change. The AOC monitors all these variables and the flight's progress by access to the same information as FM as well as via company private links. If any need to change the trajectory of the flight occurs, the AOC (after pre-warning the flight-crew) communicates with the FM sufficiently well in advance (maybe 15 to 20 minutes ahead) to negotiate and agree the new

APPENDIX 6 to
ANNEX A to the OCD

trajectory. When finalised, the AOC uploads the new trajectory data to the flight by datalink and the FM passes the details to ATM. The emphasis in these activities is on CDM and information exchange between the AOC, the flight-crew, the FM and the controller all working together to provide the optimum flight profile. In addition, the AOC maintains liaison with the destination airport to confirm or agree modification to the flight's arrival time, involving FM as necessary.

3.3 In Free-Flight Airspace

Autonomous aircraft operations are an extension of Free-Routing operations, with the difference that it was identified in the planning phases that the balance of economic benefit to users could be satisfied by the creation of FFAS. In FFAS, suitably-equipped aircraft are able to perform their own SA and are free to choose their own trajectories without requiring clearance by ATM, although they will be notified to them. There will still be a ground ATM support organisation to assist flights in difficulty or to advise if there are likely to be any local area 'hotspots' of traffic conflicts which might be beyond the capabilities of the airborne systems to resolve.

AOC's role in Free-Flight

The role of the AOC in FFAS is similar to that in Free-Routing, as described previously. The principal differences lie in if any need to change the trajectory of the flight occurs, the AOC communicates with the flight-crew to agree the new trajectory, keeping FM and ATM in the information loop and noting any advice they may provide. When finalised, the AOC uploads the new trajectory data to the flight by datalink.

Benefits: In summary, the benefits of Free-Routing and Autonomous aircraft operations for the users are that they get freedom of movement, the ability to select the best trajectory possible and to reorder their operations in response to their own objectives.

3.4 Return to Managed Airspace

As a flight in nears the end of its time in FFAS it will need to enter MAS and be integrated into the traffic flows towards the destination Airport and into the landing sequence. The flight-crew have been able to maintain their agreed trajectory and their previously agreed conditions for entry into MAS so the transition from FFAS to MAS airspace will be uneventful. However, if the agreed conditions could not be met then the flight-crew, or the AOC, would have re-negotiated their entry conditions. With the flight's re-entry into MAS, the AOC's role in the conduct of a flight is reduced, since the need to optimise the sequence of the traffic flow towards the airport takes priority over flexibility.

4 Post-Flight Phase

Once the flight is completed the AOC archives the data for the flight, flagging any areas of interest for evaluation and investigation.

Edition : 1.1   Released Issue   Page A/6/3

PAGE LEFT INTENTIONALLY BLANK

Appendix 7   Controllers' Viewpoints

1   Introduction

Today, the controllers' need to concentrate on the most important tasks in providing a service to air traffic are hindered by a number of factors, such as:

- limited information with limited accuracy (although there have been improvements in some areas in the last 20 years, mostly in the display of radar data and in flight plan Processing);

- the need to devote a considerable amount of time to communicate and co-ordinate with controllers, with the flight-crew and with others;

- working with some equipment which does not assist the controller as much as it could;

- working with systems which do not match the capabilities of those now installed in aircraft.

Advances in aircraft technology and datalink will provide the opportunity to make more information available to the controller, but research predictions are that (in the busy areas) controllers will not be able to handle the increased amount of traffic in 2015 without radical change. It is believed therefore, that in some areas controller workload will become a significant limiting factor for ATM capacity and the need for controllers to detect, select and integrate the additional information will increase rather than decrease their workload.
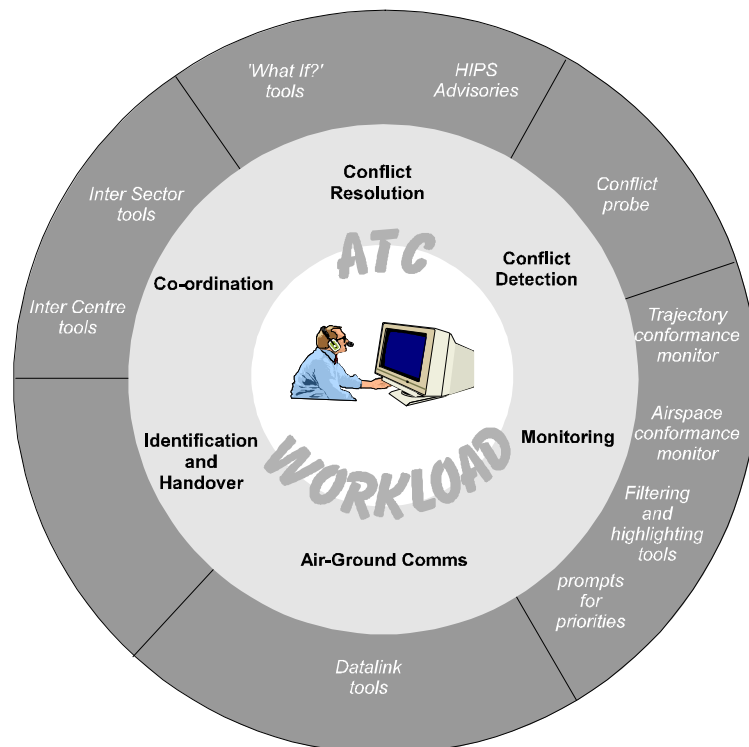
ATC Workload

2   The Future

Human involvement and commitment will be important parts of the future ATM network. It is recognised that ways need to be found to make better use of the creative, adaptive and innovative strengths of controllers and to support them with the powers of speed, reliability and consistency

of automation, in a safe, effective, efficient and user-friendly balance of human and automation capabilities. In this area R&D and Human Factors studies will help, with controllers, to determine the possibilities for capacity increases and the best balance of responsibility between controller and machine, so as to safely increase the capacity of the controller.

It is planned that automated support tools will:

- Assist the controller by the collection, analysis, filtering and processing of data so as to:

  1. provide easy to understand, more timely and more accurate information on the planned trajectories, positions and short-term intentions of flights, of the weather, on the intentions and requirements of other service providers and of the operating environment;

  2. assist with planning and tactical decision making and with the ability to preview manoeuvre possibilities, with the emphasis on the planning of separation rather than the need for tactical intervention to achieve separation;

  3. provide more accurate and reliable conflict prediction capability and to identify problems to the controller in a timely and easy to understand form so as to provide assistance in the resolution of problems;

  4. further integrate ATC systems so as to assist in co-ordination tasks.

- Enable changes to be made the controller's working practices that will ease workload, by the:

  1. redistribution of control tasks within teams or between controllers;

  2. transfer, in defined circumstances, of some separation responsibilities from the controller to the flight-crew;

  3. use of datalink to replace many voice communications;

  4. improvement of individual and team working practices;

  5. improvement of the design of controller's working positions so as to provide an efficient and user-friendly interface between the controllers and the support tools.

Other factors that will have an effect on the controller's workload will be:

- route structure optimisation based on Area Navigation techniques;

- improvements to ground movement control at airports and their integration into the overall ATM picture;

- involvement of Aircraft Operations Centres and Airports in the Air Traffic Management (ATM) planning processes.

2.1   Automated Support Systems

The systems that are foreseen as being of assistance to controllers are in the further enhancement of a number of tools that are in the development stage now, but can be expected to be proven tools by 2015. The main systems will be:

Medium-Term Conflict Detection and Resolution (MTCDR) will have the capability to detect potential conflicts up to 30 minutes in advance. It will contribute to the earlier resolution of conflict problems, the formulation of more efficient conflict avoidance manoeuvres and, coupled with other measures to reduce controller workload, such as FUA and the removal of need to align sector boundaries with national borders, will contribute to the possibility for the creation of larger sectors.

Arrival and Departure Management Systems will expand on the capabilities of today's systems, whilst keeping the controller in the decision-making loop. In multi-airport TMAs these systems will be able to handle arrival and departure traffic for different airports, or to co-ordinate with their own and other airport's Management systems and with en-route.

Arrival Management Systems (AMS)s will make better usage of available runway capacity, to provide assistance to the controller in guiding the arrival traffic and to reduce controller workload. The main functions will be to provide optimised and accurate;

- arrival time prediction;
- sequencing and scheduling;
- 4-D-descent managing;
- final approach planning.

Departure Management Systems (DMS)s will guide both 4-D-FMS with datalink and non-4-D or datalink capable aircraft into an efficient, safe and un-delayed flow of outbound traffic from an airport and through the TMA to the en-route phase. The systems will optimise flight schedules to meet ATFM, departure route and AOC considerations. Schedule amendments for equipped aircraft will be negotiated with the flight-crew via the onboard FMS and, for non-equipped aircraft, will be passed as advisories to controllers to enable them to guide the aircraft.

Surface Management Systems (SMS)s will orchestrate airport surface movements between the gates and the runways in co-ordination with DMSs and AMSs. SMSs will generate conflict-free taxi routes, and start-up and push-back timings for all controlled aircraft. Ground vehicle movements will also be integrated, by their respective agencies, with controlled aircraft movements in full coordination with the relevant ATC, airport, airline and services systems.

2.2 Air-Ground Datalink

Take-over and hand-off calls between the controller and flight-crew and the passing of non time-critical messages and clearances will be via datalink rather than R/T and so the problems of high controller workload associated with long or complicated R/T communications will be eased considerably.

2.3 Transfer of Separation Assurance Responsibility

When traffic conditions are such that it will be safe to do so, controllers will be able, under defined conditions, to delegate the responsibility for specific SA tasks to the flight-crew of suitably-equipped aircraft e.g. "station-keeping", "climb/descend when clear" etc.. Similar delegations are now part of the clearances allowed under Future Air Navigation Systems (FANS)-1 or are used in VMC by mutual agreement, but in 2015 will more extensive.

2.4 Full transfer of Separation Assurance Responsibility

Full transfer of SA responsibility is in the realm of Free-Flight (discussed later).

2.5 Summary

Not all possible ways and means to increase the capacity, reduce the workload and improve the working conditions of controllers are included, but those shown will hopefully, provide an indication of what is considered possible in the future ATM network. In all aspects however it is recognised that the concepts need to be developed and proved (against need, feasibility, cost-effectiveness and safety criteria) with the participation and co-operation of controllers, aircrew and all others involved.

3 Controller Operations

3.1 Ground Phase - Tower Controllers

Pre-Flight Phase

As today, Tower controllers will be responsible for ensuring that flights can get to the runway in time for their take-off slot and at the same time to incorporate them with all the other departing and

arriving flights in order to ensure safety and to optimise the use of the gates, ramps, taxiways and runways.

In 2015 however, controllers will benefit from increased automated decision-making support and access to considerably more data about traffic movements and intentions. The SMSs will provide controllers with real-time data on projected arrivals and departures, runway loading, airport congestion, gate assignments and environmental considerations, in order to reduce the inefficiencies in aircraft and vehicle movements that can occur today. The airport surface traffic movements will be orchestrated, under the guidance of a controller, with some movements delegated to other agencies, into an ordered interaction of movements aimed at reducing aircraft taxi times, fuel consumption and queuing, whilst maximising runway throughput, enhancing airport efficiency and improving safety.

Controllers will have data on aircraft positions and intentions and on airport hazards as well as warning information on bad weather and poor visibility conditions. The SMS, using passive and active detectors for movements on the airport surface and in its vicinity (such as sound and magnetic anomaly detectors, primary and secondary radar and ADS-B information) will provide the controller with an easily interpretable picture of forecast and actual movements on the airport and its approaches. This data will be used:

- firstly, by controllers, filtered for their specific use, to maintain a picture of all aircraft movements;
- secondly by the ground service agencies units to organise their traffic, ensuring that ground vehicles and re-positioning aircraft remain clear of active flights;
- thirdly, by flight-crew sharing a subset of the data as transmitted by datalink.

Some time before a flight-crew calls up for push-back/start-up clearance the Tower controller will have received its flight plan and the SMS, with its accurate knowledge of all airport movements will be able to provide, for the controller's approval, the most efficient taxi-route plan from the gate to the runway.

Note: The flight plan will contain a much more comprehensive description of a flight's intentions than it does today. The principal changes will be in the quality and amount of data it holds and in the dynamic nature of its contents such as:

- route or routing data will consist of 3-D points referenced in WGS-84 of x and y coordinates, allied to a z (height or Flight level) coordinate and, for 4-D flight, an associated time, (to give these a name - 3-point or 4-point fixes);
- the number of 3 or 4-point fixes needed over a specific length of trajectory will be determined by the level of accuracy required to ensure effective planning and safety;
- the flight and ground will have a complete copy of the flight plan;
- the flight plan will be updated automatically in flight (via datalink) as necessary (avoiding action, MSP or Controller alterations, AOC re-routing etc.);
- more data on performance capabilities of the aircraft will be held, either on the ground or in the air, to allow for better trajectory prediction.

The AOC would have already agreed a take-off time with FM, but the vagaries in passenger loading and other activities in the preparation of a flight means that there will be an element of uncertainty about the precise time that a flight will be ready. The flight-crew would also have been working to a target time for start-up and taxi clearance in order to meet their take-off time that took into account an approximate figure for getting to the runway, but now, with all passengers on board and the doors closed nearly all uncertainties would have been removed.

On a flight-crew's call for clearance by R/T, the controller would update and authorise the transfer of the departure taxi-route plan to the flight via datalink and pass clearances by R/T on their

required start-up time.

Datalink is significantly more efficient than R/T for transmitting and receiving long or complicated messages. Another advantage of datalink is that printed copies of any messages, clearances or instructions passed to the flight-crew will be available, reducing the potential problems of misunderstanding or mishearing. In addition, complicated taxi route instructions can be loaded automatically into the FMS (with the flight-crew's authorisation). Datalink will therefore, be especially useful for the longer messages and clearances. Voice R/T will still play an essential part in communications, where the balance of use between the two methods depends on the importance, urgency or human need for voice contact.

Ground Movement Departure Phase

With the information available, all agencies that are responsible for ground movements on the airport will have the same information on the positions and intentions of controlled aircraft moving between the runways and gates and of their own movements. The responsibility for separation can therefore, be shared between them as part of CDM. The controlled aircraft will be the responsibility of Tower and Runway controllers and will have priority over all other movements (subject to safety) and the agencies will be responsible for co-ordination with controllers and to ensure that their vehicles and movements remain clear of the flights.

Aircraft will taxi to the runway, with the flight-crews using CDTI to display a route map, along taxi routes which have been designed to minimise or eliminate conflict between departure and arrival taxi streams and to ease potential queuing or congestion problems.

In good weather and visibility a flight-crew will augment the CDTI display by looking out of the cockpit windows. If the visibility is poor however, flight-crews will see very little outside the cockpit and so they will use on-board visibility-enhancement and taxi guidance equipment to help them maintain separation from other airport users and to follow the taxi-routes in safety.

The controller and other airport operators are also assisted by a number of SMSs. By these means the interference to schedules caused by bad weather conditions is minimised and unless the weather conditions really become too bad for safe operations, the same level of throughput rates will be achieved as when visibility is good.

Of course, not all aircraft will have the same low-visibility operation support tools and here the controller can assist. Using ground-based detection systems on and around the airport, a controller can monitor all airport traffic and guide an aircraft to its destination and transmit its 'pseudo position' to the displays of equipped aircraft and ground vehicles. The controller therefore, has only to be concerned with assistance and guidance to the non-equipped aircraft.

Departure Activities
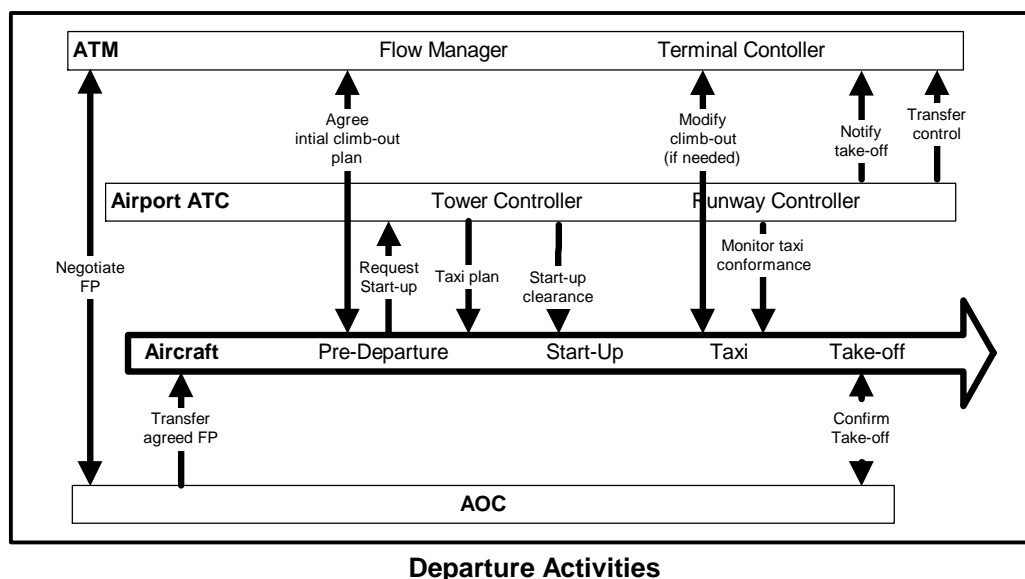
Even while a flight is taxiing, IM will enable data affecting the flight to be much more up-to-date. As soon as the destination airport is aware of any problems that will affect arrival slots, the information on the delay (cause, effect, probable duration) will be available almost instantly on the network.

The AOC, ATM and perhaps the flight-crew will be able to receive the information as 'pushed' data (data which when it changes, if previously selected by the recipient, can be displayed automatically, without the need to call it up) The decisions on what to do and which flights to hold would be worked out in co-operation with the users (in which the AOCs for various flights, and airlines would collaborate to determine which flights to delay).

Runway Controllers

Runway controllers will have access to the same information pool on aircraft predicted and actual movements as Tower controllers and will have access to SMSs that will enable them to ensure that the runways are clear of any obstacles, vehicles or other aircraft which could hazard flights. Increased navigational accuracy of flight systems and the display functions of CDTI will mean that flights will be capable of accurately maintaining the runway centre-line and to take-off even in zero visibility conditions.

> **Note:** The increased accuracy in predicted take-off times enabled by IM and effective planning in ATM means that slot allocation timings will be improved and will reduce fuel consumption and queuing problems.

4 Airborne Phases

4.1 Terminal Airspace Controllers (Departures)

The roles of Terminal Airspace Controllers will be the same as today - to ensure efficient and safe flows of traffic and to satisfy environmental and noise abatement requirements. Terminal controllers will remain responsible for SA for flights (the process of ensuring that traffic under their control, remains clear of other traffic and of other hazards to its safety, such as Danger Areas, Prohibited Areas, SUAs, terrain and weather) but partial delegation of some separation activities may be passed to the flight-crew.

Terminal controllers will be assisted by automated support systems that will expand on the capabilities of today's systems, whilst keeping the controller in the decision-making loop. Principal among these will be DMSs that will be able, in multi-airport TMAs to handle arrival traffic for different airports or to co-ordinate with other airport's Management systems and with en-route support systems.

As mentioned previously, controllers will be assisted by DMSs. The objectives of these systems will be to guide both 4-D FMS with datalink and non-4-D or datalink-capable aircraft into an efficient, safe and un-delayed flow of outbound traffic from an airport and through the TMA to en-route.

Controllers will use automated support conformance monitoring, conflict detection and resolution systems to monitor the trajectories and intentions of all flights. Conformance monitoring detects flight deviations from the agreed trajectories and determines whether they will pose a hazard. If they do not, the system will simply notify controllers of the deviations, but if they do, controllers will be alerted and recommended avoiding action(s) will be provided. Conflict detection and resolution systems monitors all other traffic in the TMA and provides the same services as conformance monitoring if potential conflicts are detected.

During climb-out flight-crews will monitor their flight's conformance to its planned trajectory, which is guided by the FMS. Although the responsibility for SA is with the Terminal controllers, partial delegation of some separation activities may be passed to the flight-crew. It is essential therefore, for flight-crews to maintain their own situational awareness and to do this they are assisted by the ASAS. ASAS will supply data on the position and short-term intentions of all other 'collaborating' flights within the area of interest, which will be displayed to the flight-crew via the CDTI.

Terminal controllers, using ground-based as well as air-based detection systems will have more data on the traffic environment than the flights themselves. For traffic that is not ASAS-equipped, Terminal controllers will be able to correlate data on them and to use ground-based equipment to imitate data from the flight, so that they can be detected by ASAS.

Transfer of control from Runway to Terminal controllers will be silent and performed automatically by automated support systems. Similarly, 'contact handshakes' between flight-crew and controllers (now done verbally by the flight-crew and controller) will be performed automatically via datalink and the FMS. The transfer will be initiated as part of the hand-off procedure, the flight-crew will be advised of the change and they or the controller will be able to over-ride the process at any time.

4.2 Centre Supervisors

Centre supervisors will be able to match the capacity of their Centre and of the individual sectors to the traffic flow characteristics by dynamic re-sectorisation and by changes to the route structures. These route changes and re-sectorisations will be made:

- via a known finite set of possible organisations, made at specific times (not on an ad-hoc basis) and which will be co-ordinated with other sectors and centres;

- all ground-ground and air-ground communications facilities and links together with the display of sector and flight data will be re-configured and re-routed automatically.

4.3 En-Route Controllers

The role of the En-route controllers will have a significant number of changes, depending on which of the two types of airspace regime they are operating in - MAS or FFAS.

Managed Airspace

In MAS, aircraft will either be operating in a route structure (Structured Route flight) or flying on a user-preferred trajectory (Free-Routing).

Support Systems

En-Route controllers will have a number of automated support systems to assist them. These systems will be the same as those used by Terminal controllers, but with additional functions tailored to satisfy the different needs of controlling traffic in a structured route environment, such as:

- MTCDR systems that will have the capability to detect potential conflicts at up to 30 minutes in advance and to assist the controller in the resolution process;

- conformance monitoring systems.

### Working Arrangements in Managed Airspace

In Route-Structured Airspace

The controller's role in 2015, where based on the principles of a Tactical Controller operating in a sector, will be similar to that of today; there is also the possibility however, of a move away from sectorisation to a method where controllers are allocated individual aircraft or flows of traffic in the airspace. Research on the current sector working arrangements shows that it will be inadequate to handle the increase in traffic by 2015. One answer, in the past, to the problem of increased traffic has been to make sectors smaller. Many of the majority of sectors in Europe have transit times of less than 15 minutes, and some can be as short as 5 minutes. As said before however, MTCDR systems will be able to predict and assist in resolving potential conflicts up to 30 or so minutes in advance and so will be of benefit to controllers in larger sectors.

In most, if not all, Centres in Europe, sectors are currently fixed in size with the only adjustment being to amalgamate two or more sectors into one when traffic levels permit. In 2015 however, it will be possible to adjust sector dimensions to respond to traffic flow demand, caused either by the diurnal variation in traffic flow, by weather or by changes in the airspace caused by SUA activation or release.

Automated support tools will allow for the introduction in areas where the density of traffic makes their use necessary, of MSPs to oversee a number of sectors and be responsible for the resolution of medium-term traffic problems, to manage and balance the complexity of traffic flows and so ease the controllers' workload.

The sectors for which MSP will be responsible will be aligned around major traffic flows, either in one Centre or across the boundaries of two or more (whichever provides the best means of working) and will use the intentions data on 4-D-capable flights and ground-based prediction path data for 3-D-capable flights to predict their positions (adjusted with probabilistic errors to allow for prediction inaccuracies and minor non-conformance by the flights). When problems are detected, MSPs will judge the action necessary to resolve them (a number of factors will affect this decision: weather, prediction accuracy and the knock-on effect on other flights) and, if appropriate, negotiate flight changes with other MSPs and the controllers affected.
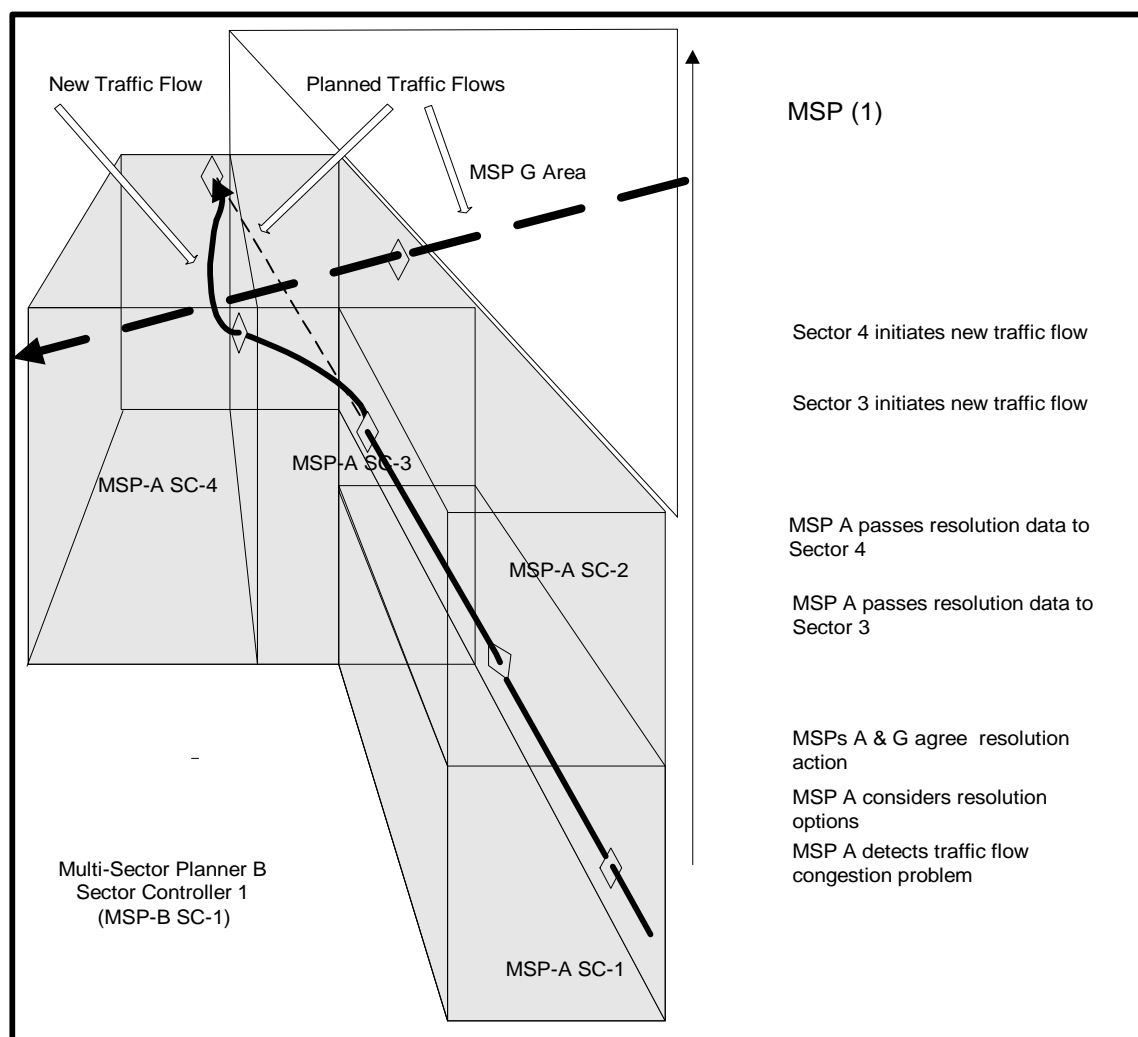
MSP Traffic Flow Problem Resolution

In Free-Routing Airspace

In most airspace and most of the time the high capacity demands that force the need to create route structures in MAS (even though they are dynamically alterable) are not necessary. Under these conditions MAS can accommodate user-preferred trajectory operations in which flights choose their own trajectories whilst remaining under ground control for SA (Free-Routing).

The controllers' role in 2015 will be essentially the same. They will still be responsible for ensuring SA (although some separation responsibilities may be partially delegated to the flight), but the manner in which they carry out their work will have a number of important differences. Basically, the initiative for making decisions on where and when a flight will go will rest with the aircraft operators and the controllers responsibility will be to resolve the conflicts that may be caused by those decisions. Because flights are operating in a known environment and the aircraft operators have access to the relevant information, the obligation to select trajectories or trajectory alternatives that will not interfere with other flights remains firmly with the aircraft operators (either AOC or flight-crew).

The use of support tools to provide look-ahead simulation and analysis will reveal patterns in the planned traffic that will enable Centre supervisors to satisfy demand and resource capabilities by determining the Centre's sectorisation and/or allocation of individual flights to specific controllers, plans.

4.4 Free-Flight Airspace

Forecast traffic flow densities and the capabilities of the flights will mean that in some airspace, demand for capacity will not be the major issue and more priority can be given to the operators' quest for flexibility and for economic routing. Accordingly, during the Optimal Flow Regulation Phase, a flexible but managed allocation of FFAS will be defined for a particular area, above a certain level and/or for a set period of time.

Support Systems

Free-Flight controllers will also have a number of automated support systems to assist them. These systems will be developments of the same systems used by the Terminal and En-route controllers but with the addition of some functions and the reduction of others to tailor them to satisfy the different needs of providing a service to flights in FFAS, such as:

- MTCDR systems that will have the capability to detect potential conflicts up to 30 minutes in advance and to assist the controller in the resolution process;

- conformance monitoring systems.

Working Arrangements in Free-Flight Airspace

Roles and Responsibilities in FFAS will obviously be quite different to those in MAS. In summary: in Free-Flight the flight-crew are responsible for SA and for maintaining their agreed trajectory; the AOC for optimising it in the company's interests; FM for providing advice to the AOC; and finally the Controller for maintaining contact with the flight to provide any direct advice or assistance.

The flight-crew will use data from ASAS as shown on the CDTI, to provide a full picture of the civil air traffic situation around the aircraft (military flights may be included in this picture - if permitted by the military) that will enable the flight-crew to maintain their situational awareness of surrounding conditions (probably up to 120 nm. forward radius and less to the sides and rear). The functionality of ASAS will now come into its full role of ensuring the safe separation of the flight from other aircraft and hazards. When a flight's ASAS detects a potential conflict it will use EFR (a development based on the Rules of the Air in UMAS) to determine which flight has priority over the other and will formulate, in collaboration with the other involved flight(s) and their flight-crews, the avoiding action to be taken (priority will be given to special flights, such as those in emergency or performing a specific task which limits their manoeuvrability).

The AOC will oversee the flight and continue to balance the flight's schedule against the airline's needs. If any need to change the trajectory or priorities of the flight occur, the AOC communicates with the flight-crew to agree the new trajectory, keeping FM and the Controller in the information loop. The FM and the controller, because they will have a more extensive view of the actual and predicted air situation, will advise the AOC or flight-crew on the safety impact of their desired actions. Once again the emphasis will be on collaborative decision-making and information exchange with the AOC, flight-crew FM and controller working together to provide the optimum flight profile.

For the controller, the primary role changes will be that there will be no responsibility for SA or flight guidance (perhaps a different job title will be used). Controllers will have data on the flight plans of all aircraft as well on their real-time positions and intentions and so will be able to work to a greater time-horizon than the flights or AOCs. Using automated support tools they will be able to recognise potential congestion areas (not necessarily individual conflicts) some time in advance of the flights and will be able to issue 'Safety Advisories' if there is a threat that conflict problems caused by congestion may exceed the capacity of ASAS to resolve.

If a flight experiences a failure that means it can no longer meet the conditions for operation in FFAS, the controller can assist it to continue or to descend into MAS(depending on the circumstances). It can also be envisaged that the controller will act as a referee, ensuring equity and that flights conform to the rules of operation.

Benefits: In summary, the benefits of Free-Flight for the users are that they get freedom of movement, the ability to select the best preferred trajectory possible under the prevailing conditions and to reorder their operations in response to airline objectives.

Return to Managed Airspace

At some stage flights may need to return to MAS and be integrated into the traffic flows.

A flight's entry into MAS has to be co-ordinated with ATM. If the flight-crew have been able to maintain their agreed trajectory the transition from FFAS to MAS will be uneventful because the previously agreed conditions will have been maintained.

If however, the flight will not arrive at the agreed entry point at the agreed level and time and with the agreed flight conditions the entry will need to be re-negotiated. The negotiation to re-enter could be between the AOC and FM or between the flight-crew and the en-route MAS MSP or controller, depending on:

- the flight time to the FFAS/MAS boundary;
- whether the MAS is Free-Routing or Structured Route;
- the distance from the boundary to the airport.

  Note: An advantage of an airborne over a ground entry is that the entry time forecast from an airborne flight will be more accurate and reliable than that from a runway departure forecast - current research shows that an airborne aircraft can achieve a positional accuracy 20 minutes in advance of +/- 5 seconds.

Once the flight transits into MAS there are two options for its mode of flight:

- firstly, dependent on traffic density, the flight-crew could retain responsibility for their own SA in Free-Flight mode;
- secondly the ground system would take over responsibility for SA.

4.5 Terminal Airspace Controllers - (Arrivals)

For areas where traffic density is not too high or airport capacity and throughput are not the most pressing problems, the ability to offer airspace users freedom and flexibility of movement will be retained. The most beneficial general approach procedures for flights (remember, real-time weather conditions will not be the same as those forecast) would have been agreed between the AOC and FM, detailed in the flight plan and up-linked to the flight's FMS.

As flights approach their destination the AMS will up-link the latest weather actuals, the agreed time, position and flight conditions for the initial approach fix (level, heading, speed) and details of areas to be avoided in the approach. Flight-crews will then determine their approach path in negotiation with the TMA controller. The controllers task will be similar to that for departures, using conflict detection and resolution and conformance monitoring systems to assist them.

In busier areas, the integration of traffic into landing sequences will be a more complex process in which the need to ensure airspace capacity or to ensure that the runways at a busy airport are used to maximum efficiency will take priority over the individual optimisation of flights in order to ensure overall efficiency of operations.

> **Note:** The AMS has been receiving updates on the progress of flights and, at the appropriate time, starts to assess the impact of a flight's approach on the established arrival sequence and to formulate how to integrate it in order to ensure optimal use of runway and airport capacity. Using its knowledge of the flights performance capabilities and preferences contained in the flight plan and the known position and intentions of the flight, it formulates a 4-D trajectory for descent and approach for the flight in which its aim is optimising the top of descent, whilst planning a trajectory that will mean that the flight achieves its planned landing slot time.

TMA controllers (arrivals) supervise the AMS to ensure safety and equitability and negotiate the proposed 4-D trajectory with the flights (passed to the flight by datalink) and flight-crews either agree it or negotiate alternatives until a trajectory is agreed.

> **Note:** Principal aims for arrivals management at a busy airport are to fill the gaps in what could be an irregular arrival sequence and to avoid the bunching of flights. At peak periods this can be done by funnelling flights through a short-duration hold to smooth out the irregularities and keep delays to a minimum. Flights in the TMA may also have speed constraints imposed and in extreme circumstances may have to enter a holding pattern. If the runway utilisation problem is not as pressing, there may still be the need to modify the flight arrival trajectory by the use of route adjustment to give or make up time to allow for aircraft with different approach speeds.

The agreed trajectory data is set in the flight's FMS and when appropriate, the flight begins descent in the initial stage of the approach. Similar to climb-out, the flight-crew monitor and confirm that the aircraft's FMS is guiding the flight in conformance with its planned trajectory, assisted by ASAS to maintain their situational awareness and ACAS as a safety-net to help prevent collisions between flights.

Once an arrival time for the flight has been established, the SMS determines the optimum taxi route for the aircraft to its gate and this data is up-linked to the flight via datalink.

As the flight enters the arrival traffic stream, the flight-crew can see, either visually or by ASAS, the other flights in the stream and monitor that their separation and in the intermediate and final stages of the approach the flight-crew may be requested to provide self-separation from other traffic in the approach.

> The AMS will act in co-operation with the DMS to balance the relative priorities of arriving and departing flights. As well as data on all flights in the TMA, the AMS will also receive timely and accurate data on the weather (from weather forecasts, aircraft now-casts or ground-based weather radar) and so the controllers will be able to adjust the route structure in response to weather conditions before, rather than when, they become a problem.

Depending on the extent of the coverage of the AMS and the severity of the arrival sequencing problems it may request that the trajectory of a flight is adjusted whilst it is still en-route. This would be achieved by negotiation with an En-Route controller, or an MSP (if present) in agreeing a new entry time or point into the TMA. The flight's trajectory would, if possible, be adjusted and the controllers affected by the change be notified. The adjustment, as now, could be to speed or track delay measures or descent before the optimum descent point.

Arrival sequencing requirements will be prioritised by the demands of service quality plans with airlines or individual flights and, with the provision of equitable service to other arrivals and departures. and will take precedence over the wishes of the AOC.

5   Ground Movement Arrival Phase

While a flight is in the approach and landing phase, the SMS, (in negotiation with the Departure and Arrival systems) will plan the most appropriate taxi-plan to take the flight to its gate. The taxi-plan is passed to the flight via datalink either before landing or during the landing run.

One problem that could arise is that an aircraft capable of landing in bad visibility or weather might not have the on-board capability to taxi to its gate. In these circumstances the Tower controller will have the facilities of SMSs to guide the flight to its gate.

Using ground-based detection systems on and around the airport, the controller can monitor and guide an aircraft to its destination and transmit its 'pseudo position' to the displays of equipped aircraft and ground vehicles. In this way the controllers' problems are eased since it is only necessary to be concerned with detailed assistance and guidance to the non-equipped aircraft. With these automated tools, the controller can monitor all airport traffic and ensure that they conform to the clearances given and provide assistance and guidance if needed.

Appendix 8   Flow Management's Viewpoint

1   Introduction

The Flow Management Viewpoint is based on FMs in a CFMU working in co-operation with airline representatives at an AOC. In circumstances where there is no AOC, FMs will act, still under the rules of equity, in the interests of the airspace user who has less capability for optimising their flight. However, it should be realised by airspace users that the more capable an aircraft is the more likely they are to realise the full benefits of the future ATM network.

The wide range of airspace characteristics (traffic densities, traffic flows, airspace organisation etc.) means that, although the ground system will provide a seamless service to the users, the type of ground organisation will be different in different areas. For example, some areas may not need to utilise MSPs and the FM will co-ordinate directly with controllers. In other areas, where MSPs are utilised, the hand-over point at which the MSP takes over responsibility for planning will vary according to the conditions.

2   Flow Management Developments

The current CFMU emphasis in dividing the available capacity as equitably as possible between the different traffic flows so as to distribute delays will change. It will transform into a system where operations will be conducted in an integrated and collaborative partnership with both airspace users and ATM service providers. This collaboration will, using the principles of IM and CDM to share responsibility, ensure that the person best able to make a decision is the one who does so.

In 2015, an FM will have more comprehensive, more timely and more accurate data on the current and forecast traffic demand and on airspace and service provider capacity in Europe. This data will be derived from the DOP, provided by the planning processes, and from real-time traffic data. This will enable the more efficient management of airspace and service provider resources to meet traffic demand. Such data will include, for example:

- traffic flows;
- weather;
- en-route Centre capabilities;
- user demand;
- airport traffic acceptance and generation capabilities.

2.1   Sharing of Responsibilities

Decisions on when a flight should depart and the route, routing or trajectory it will fly will be delegated to users whenever possible so that they will have greater opportunities to meet their objectives. This will be effectively a partnership of sharing information and decisions to optimise flight operations, to reduce cost and delay and to maintain safety and equitability.

2.2   Collaborative Decision-Making

CDM uses the exchange of data (provided by IM) between users and service providers to improve the decision-making process by the sharing of up-to-date information. It will give the responsibility for making user-operational decisions to the users, within sets of established procedures, where AOCs focus on efficiency and the airlines' business objectives, with a significantly greater opportunity to meet their goals and to retain operational control over individual flights, while CFMU focuses on the provision of capacity, safety and equity among users.

Note: The balance in CDM will depend on the level of capability of the user to undertake these responsibilities, on the service quality agreements between the CFMU and the user and also may be constrained by the complexity or traffic density in certain areas at certain times.

Information Management

Efficient IM will be essential to support the increase in the exchange of the volume, quality and timeliness of the operational data on which the functions of future CFMU operations will be based.

As well being able to gather data on their operations, either through ATN or their own data networks, IM will give users access to a subset of the same 'picture' (subject to the confidentiality of some data) of the air traffic situation over Europe as FMs and service providers. This will mean that the negotiation process between an AOC and an FM will be a lot easier since more complete knowledge of the current and forecast traffic situation can be taken into consideration when planning flight trajectories.

Note: Considerations of Commercial-in-Confidence, Military, National Security considerations and the need to guard against malicious intent will mean that some data seen by FMs will be deleted or selectively filtered before it is released to users. Thus, while users will have more knowledge of the air situation in the future than now, they will not have all of it, reinforcing the requirement for FM.

2.3 Automated Support

Automated support systems will enable FMs to see a picture of current and predicted traffic movement throughout Europe on 'Situation' Displays, that will show real-time data, such as:

- static data:, airports, ground-based navaids, permanent airspace restrictions, etc.;
- dynamic data: routes, sector and Centre boundaries, flights (position, intentions, flight plans), adverse weather, winds, SUA states, Sector and Centre capacities and unserviceabilities (effect on service, time-to-repair).

An FM will have the ability to drill-down from the overall picture of the current and predicted air situation to selectively identify and display the data of individual flights and will be able to:

- share strategic and tactical decisions on the traffic and flight movements in collaboration with airspace users and service providers;
- if necessary, predict when, where and for how long capacity will need to be adjusted to meet demand.

3 Where Flow Management fits in to the future ATM

Flow Management will provide the top two layers in SA. The purpose of SA is to ensure that aircraft operating in the Air Traffic environment, both on the ground and in the air, are separated from hazards to their safety. A hazard may be:

- other aircraft, on the ground or in the air;
- restricted, prohibited or danger airspace;
- terrain, minimum safe flying level, safety altitude etc.;
- atmospheric conditions (severe weather, wake turbulence etc.);
- static or moving ground obstacles, other than aircraft.

Safety Layers

The first is a planning and control layer that helps to ensure an efficient overall traffic flow and which uses all resources to best effect. This will be in an upgraded CFMU, capable of balancing the capacities of the airports and en-route airspace with the available resources so as to optimise

the traffic flows. It will manage this by collaboration with AOCs, En-route Centres, and departure and destination airports, to apportion traffic so as ensure a manageable workload for controllers, to ensure avoidance of hazardous weather and to meet the aircraft operators requirements.

The second layer operates at a tactical level on an overall picture of active traffic when the uncertainties in the first layer are reduced by the knowledge of actual flight times. Here FMs will sequence and separate flows of traffic and balance capacities. They will do this in close collaboration with MSPs (where utilised) by examining the overall traffic picture to identify where traffic congestion may cause overloading of resources in Centres to occur or where developing weather may cause a problem and, in co-operation with the AOCs, aircraft and Centres, will regulate and reorder the traffic flows. They also, of course, will seek to optimise the traffic flow by taking advantage of the opportunities to shorten flight trajectories, for example by re-routing traffic through recently released SUAs.

4 Flow Manager

An FM is a major interface between airspace users and ATM in the Pre-Flight phase and on the day of flight. The type of user may vary from AOCs representing their own airline's flights, agencies providing services to a number of operators, the military or individual pilots.

4.1 Tactical Flow Planning and Pre-Flight Phases

At some stage prior to the flight, the user has selected the best flight profile for the airline's purposes and submits it, over the ATN to an FM for agreement.

An FM examines a flight plan request to see if it is acceptable or if there are any potential resource, capacity or congestion problems that the user was unaware of. If there are problems the FM will identify cost-effective solutions in co-operation with the user, giving the user the freedom to choose the most optimum flight. If however, safety levels or equitability might be compromised, the FM will be the final arbiter and will determine the flight plan.

> **Note:** The FM uses automated support tools to assist in evaluating the effect of the proposed flight plan and to identify any factors that may affect the flow of traffic (en-route Centre serviceability, runway closure, weather etc.). For scheduled and pre-planned flights most of these problems would be resolved by the AOC, but the balance of decision-making would tilt towards the FM in the case of short-notice requests for access by additional flights or changes by scheduled and pre-planned flights.

Communications between the FM, airspace users and service providers will normally be over an information exchange network (ATN, telematics links etc.). Routine event inputs and changes are checked by automated support tools and processed (with the FM kept in the information loop). Non-routine changes or events are notified to and handled by FMs.

Once the details of the plan are agreed, either by changes to the flight plan or to the resource and capacity levels of en-route Centres, it will be distributed automatically to all interested parties. (e.g. Centres, destination airport, military etc.).

Other users, besides scheduled and pre-planned flights, will also want fast and easy access to the airspace and they need to be catered for in the future ATM network. Users who do not have an AOC (for example, small airlines and GA) will also have access to an FM. These users plan and get their flight plan accepted using the facilities provided by IM and the ability of the user to choose the data that are wanted. The choices ranges from:

- employing the services of a multiple-customer-type AOC;

- data a flying association (such as AOPA);

- data from service providers who charge for their services or that may be provided free by national and international organisations.

All these services (which, in the interests of safety, will have to be regulated and validated) will be available via the Internet or on the ATN and will provide all the facilities and communications needed to plan a flight and to negotiate and agree it with FM.

Flight Delay

IM will mean that data affecting the flight will be much more up-to-date and available. For example, as soon as a destination airport is aware of any problems that will affect arrival slots, the information on the delay (cause, effect, probable duration) will be available almost instantly to all interested parties.

The AOC, ATM and maybe the flight-crew will be able to receive the information as 'pushed' data (data which when it changes, if previously selected by the recipient, can be displayed automatically, without the need to call it up) The decisions on what to do and which flights to hold would be worked out in co-operation with FM and the users.

5   Airborne Phases

Once a flight is active, an FM is involved in:

- estimation of the long-term flow conditions that may affect it;

- estimation of the possible impact of new flights on it;

- responding to requests for changes to its flight plan.

Long-term Flow Management

Long-term Flow Management covers the period from approximately 90 to 20 minutes in advance of the flight and has different responsibilities in Structured Route flight, in Free-Routing flight and in Autonomous Aircraft operations.

> **Note:** In MAS aircraft will either be operating as flights in airspace which has a route structure to meet requirements for capacity and safety (Structured Route flight) or which has no route structure, in which flights decide their own trajectory (Free-Routing).

Traffic in Structured Route Flight

Traffic in Structured Route flight is under the control of ATC, who are responsible for maintaining SA. More accurate aircraft navigation capability, automated support to controllers for trajectory prediction and conflict resolution will allow for the use of reduced vertical and horizontal separation minima, thereby enabling greater traffic densities to be achieved. However, the volume of traffic can be expected to be very high and the need to satisfy capacity demands and overall efficiency will, at some times, have to restrict the operators desires for individual freedom of operation.

The route structure will not be static. At times in the day when the traffic density or the flow pattern is different, the airspace, routes and sector and Centre boundaries, which had been optimised to accommodate the traffic characteristics, will be restructured to adjust to meet the new traffic demand, (these restructuring plans were determined in the Planning phases).

The FM's responsibility in Structured Route airspace will be to liaise with Centre supervisors, MSPs or Sector Controllers (depending on the control organisation used) to agree strategies for traffic flows, or plans for individual flights, in order to satisfy constraints, to realise opportunities or to respond to requests from a user for alterations to a flight, the effects or implications of which are beyond the time-horizon of the Centre itself.

Traffic in Free-Routing Flight

Traffic in Free-routing flight is also in MAS in which SA is the responsibility of ATC. Here, although more accurate aircraft navigation capability and automated support to controllers for trajectory prediction will allow reduced vertical and horizontal separation minima and therefore, greater traffic densities to be achieved, the density levels will be such that a route structure will not be needed and airspace users will have the freedom to select their own trajectories.

The role of the FM will, accordingly, change to take on more of the decision-making responsibility in acting as the focal point between users and service providers to agree trajectories for flights, to evaluate the long-term impact of proposed flight changes, of changes to airspace (e.g. SUA closures) and of changes in service provider capabilities (e.g. unserviceabilities etc.).

5.1   Traffic in Free-Flight Airspace

Although FFAS is the realm of autonomous aircraft operating independently of the ground, CDM and IM still have a major part to play. The flights are in a 'known traffic' environment since their planned trajectories have been notified to ATM and they can be expected to be in stable trajectories (FFAS is not 'ad-lib' airspace and high-energy manoeuvres are not compatible with the needs for economy or passenger comfort).

Aircraft in FFAS are not totally alone. As described in the OCD 'There will be a continuing need for a ground based ATM element', and this applies in FFAS as well as MAS. The ground-based ATM element will provide a 'Safety Support' service to assist any flights which may get into difficulties, and, because of its more extensive knowledge of aircraft positions and intentions, ATM will provide a 'Safety Advisory' service to warn if specific local areas might get too congested for safe autonomous separation.

Roles and responsibilities in FFAS will obviously be quite different than those in MAS. In summary: in Free-Flight the flight-crew are responsible for SA and for maintaining their agreed trajectory; the user for optimising the flight trajectory; the FM for providing advice to the AOC and liaising between users and service providers; and finally the controller for maintaining contact with the flight to provide any direct advice or assistance.

In particular, the FM will have no decision-making responsibility. Instead, FM will be responsible for the provision of advice on the user's decisions, to identify and highlight potential problems and to assist the user to determine a course of action for the flight. Once the user's decisions are notified, the FM ensures that Centres and controllers are informed.

The AOC (or other user capable of doing so) will still oversee the flight and continue to balance the flight's schedule against their needs. Any flight plan modification desired is notified and negotiated with ATM, as described previously. When agreement is reached, the AOC notifies the flight-crew and uploads the new trajectory data to the flight by datalink. The AOC maintains liaison with the destination airport to confirm or agree modification to the flight's arrival time, involving FM, as necessary.

   Note: For users without an AOC: These operators, will still be able to optimise their trajectory, but the extent to which they can take advantage of the information in the future ATM network will depend on their level of capability.

PAGE LEFT INTENTIONALLY BLANK

Appendix 9   Essential 'Future ATM network' Enablers

1   Preamble

The previous appendices have illustrated the Target Concept from the viewpoint of various ATM decision makers or functional decision making processes in the air transport system. This appendix looks at issues from the viewpoints of two essential enablers for the future ATM network:

- CDM - the means by which decisions can be reached;

- IM - the management of the *decision support information* which is circulating in the air transport system.

2   Future ATM network Enablers

2.1   Collaborative Decision-Making

Collaborative decision-making is the process which allows decisions about events to be taken by those best positioned to make them (i.e.: aircraft operators make decisions about their operations; service providers make decisions about ATM resources such as airspace, route structures, etc.). It is an essential element of the gate-to-gate approach to the management of flights.

The collaboration aspect relates to the need for all relevant information to be shared between the parties involved in making decisions. Decision making follows as a normal operational process, but decisions will be of a better quality and engender greater confidence because accurate and validated information will be available in the right form, in the right places at the right times.

An open systems environment and better IM will allow information sharing on a much wider basis than hitherto, and support a permanent dialogue between the various partners - ATM, Aircraft Operators' Operations Centres, Pilots and Airport Operations, etc. - throughout all phases of flight.

This exchange of information will enable the various organisations to update each other continuously on events in real-time. Thus, aircraft operators will have up-to-date and accurate information on which to base decisions about their flights, while ATM and airports will have a better knowledge of flight intentions for operational and planning purposes.

There will be a number of other interested parties who need information to improve the service that they supply to - or receive from - ATM, such as customs and immigration authorities, who will benefit from more accurate arrivals and departure information. The combinations of partners involved in any particular decision process are numerous. For example, some decisions will concern just the airport authority and aircraft operators (refuelling times, etc.), whereas others will need to involve all parties (changes to departure times, etc.).

CDM can be considered to be both active and passive, and applies at all layers from longer-term planning activities through to real-time operations. There will be occasions when communication and negotiation between the parties involved will be required to resolve a problem or meet a request for change (e.g.: by aircraft operators for the sequencing of their aircraft for operational reasons), but in many instances decisions will be made by just one of the partners based on information supplied by the others (e.g.: to fly a particular route to avoid forecast congestion points). An essential pre-requisite is that every participant keeps the information for which they are responsible accurate and timely.
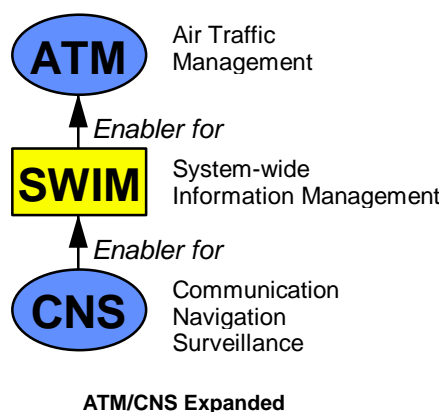
2.2 Information Management

Although this appendix uses some terminology more familiar to Information Technology (IT) specialists than ATM experts, readers are advised not to see IM as a technical issue. Subjects such as the integrity, availability, use and life-span of information are purely operational. Hence IM itself should not be confused with the technical solutions underpinning the operation of IM.

IM deals with issues common to all kinds of ATM information used and/or produced in support of ATM, e.g. in the context of ASM, ATFM, ATC, MET, AIS, flight planning, airline flight operations etc.

Information sharing and *collaborative decision making* have been identified as fundamental elements of the ATM target concept which will rely increasingly upon increasing amounts of (digitised) information used in more automated and integrated/networked ways.

However, up to now, ATM information management for different types of information has evolved independently based on subsystem- and service-specific operational requirements, resulting in a large diversity of mechanisms and principles. As a result of this bottom-up approach, today's ATM network is very much an insufficiently integrated collection of people, systems and networks each dedicated to handling their own kind of information. The bottom line is a series of technical, organisational and institutional barriers which prevent easy and timely use of relevant information.

The answer to the IM challenge is not simply a matter of better communications, navigation and surveillance. Neither is it sufficient to introduce 'smarter' decision-making concepts in the core ATM processes. The missing element in the "ATM/CNS" acronym is *information*. ATM needs it; CNS helps to provide it; but once large amounts of it are circulating in a distributed environment, it needs to be properly *managed*.

ATM — Air Traffic Management

Enabler for

SWIM — System-wide Information Management

Enabler for

CNS — Communication Navigation Surveillance

ATM/CNS Expanded

Thus, the key supporting enabler below the core ATM processes but *above* the CNS enablers (i.e. supported by the latter), is the system-of-system's ability to handle the *logistics* of information sharing in the future information-rich networked ATM environment (see 'ATM/CNS Expanded')

In an information-rich environment, the IM problems are of a macroscopic nature. They differ fundamentally from those in today's ATM network[27]. Hence the need for a different approach and the introduction of common IM concepts and mechanisms.

The future information-rich ATM environment — consisting of a large number of distributed collaborative decision making nodes — will also be more fluid and self-organising than today. The target concept must assume that in the long-term future, the ATM stakeholders (producers and consumers of ATM information) will need to share information in ways, at times, at locations and over interfaces which were not always foreseeable at system design time. This is in strong contrast with the present method of evolving the ATM network, which is based on designing ('hard-wiring') the information flows into the operational procedures and (sub)system interfaces at standardisation or system design time. Today, changing needs for information sharing or collaborative decision making inevitably lead to time consuming and costly re-engineering of systems, interfaces, standards and operational procedures.

---

[27] For example, information security is very poorly addressed in today's ATM network. It becomes a major issue in an information-rich, networked, safety-critical, national security and commercially sensitive environment.

The System-wide Information Management Concept - The ATM target concept approaches the IM subject via the *System-wide Information Management* concept, implying that IM solutions will be defined at the overall system level, rather than at each major subsystem (programme/project/process/function) and interface level individually as is happening today. The solutions will be compatible with the future IM concepts of the interacting stakeholders (airspace users, airports, military systems, MET service providers etc.), which are in turn driven by opportunities offered by the evolution of the IT industry. The whole subject goes well beyond the responsibilities and capabilities of individual ATM network components or interfaces.

The System-wide Information Management concept aims at integrating the ATM network in the *information* sense, not just in the *system* sense. This fundamental change of paradigm forms the basis for the migration from today's one-to-one message exchange concept (see 'Information Exchange Model') to the future many-to-many information distribution model (see ATM Pool Model') — many geographically dispersed sources collaboratively updating the same piece of information, with many geographically dispersed destinations needing to maintain situational awareness with regard to changes in that piece of information).
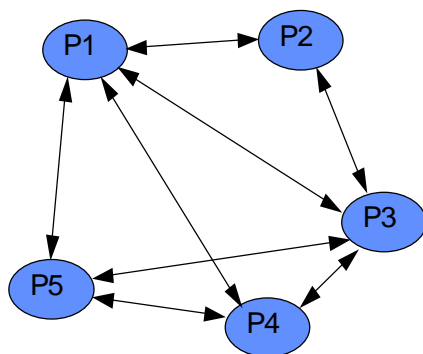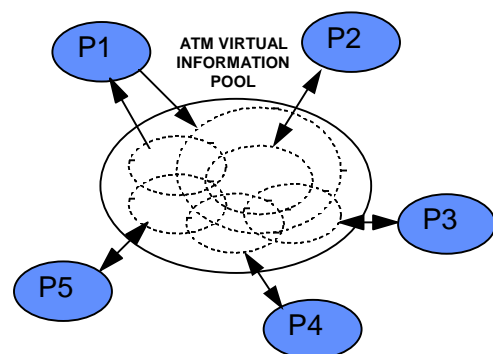
Information Exchange Model   **ATM pool Model**

The aim of System-wide Information Management is to ensure that the information needs of ATM stakeholders — both within as well as outside the ATM network — will be satisfied in a much more flexible and cost effective manner than today. **This goal will be achieved** by bundling the forces of all suppliers of ATM information, to assemble and continuously maintain the best possible **integrated** picture of the past, present and (planned) future state of the ATM situation, as a **common** basis for improved decision making by all ATM stakeholders during their strategic, pre-tactical and tactical planning processes, including real-time operations and post-flight activities.

Successfully managing the quality, integrity and accessibility of this complex, growing web of distributed, fast-changing, shared ATM information called the virtual **ATM pool**, is the main operational enabler for the Target Concept.

Components of System-wide Information Management - are conceptually subdivided into the following subjects:

- information ownership, licensing and pricing;
- information security management;
- ATM pool content management;
- the information acquisition process;
- the information dissemination process.

Information Ownership, Licensing and Pricing - Information will be a commodity in the future information-rich ATM network, not just in the strategic planning phases, but also during real-time operations. However there are commercial sensitivity and national security considerations, as well as the interests of commercial information service providers.

Information ownership, licensing and pricing are issues which are related to, but distinct from security and communication cost aspects.

Certain ATM information provided by stakeholders within or outside of the ATM network will be shareable without restrictions. For other information, the suppliers may want to charge a fee, restrict dissemination and/or retain ownership and control after dissemination.

As part of *ATM pool Content Management* (see below), arrangements will need to be made (similar to 'letters of agreement') to establish security levels, the willingness of stakeholders to provide certain information, gain access to information, play certain roles in CDM, and compensate or charge the stakeholders accordingly in financial or other terms. The 'letters of agreement' will establish the legal basis; for daily operational application they will be translated into appropriate 'adaptation parameters' governing the continuous operation of the various System-wide Information Management sub-processes throughout the ATM network.

Information Security Management - In a collaborative distributed environment, where technical, organisational and institutional barriers to the access of information have been drastically reduced, security is of utmost importance.

Consistent and compatible mechanisms will exist to handle the security aspects of information collection, content management and dissemination throughout the ATM network.

The principle of subsidiarity will be applied in security matters: physical storage and security management will be as close as practicable to the information owner.

ATM pool Content Management - A common, up-to-date shared view of all relevant ATM information (**the ATM pool**) will be maintained in a distributed stakeholder environment in accordance with defined scope, quality and integrity requirements. To achieve this, a (distributed) ATM pool Content Management process will continuously:

- evaluate the need for shared information across all components of the ATM network and its interfacing stakeholders;
- evolve the common data models and formats in line with changing information needs;
- maintain the information ownership, licensing, pricing and security framework;
- monitor the (distributed) contents of the ATM pool against the need;
- manage identification and naming of information objects in the ATM pool;
- track the dynamic relationships between information objects in the ATM pool;
- predict and detect problems with information quality and integrity;
- co-ordinate the information acquisition and dissemination processes (see below).

The Information Acquisition Process - The ATM pool always needs to reflect the latest state of affairs, and hence a continuous inflow of updates from a variety of information suppliers needs to be guaranteed. To this effect, (distributed) information acquisition processes will continuously — for each type of shareable information:

- determine whether or not the information needs to be shared, i.e. be present in the ATM pool;
- maintain an overview of potential sources/suppliers of that information;
- qualify and compare the available information streams;
- dynamically maintain a selection of one or several sources of input;

- for each source of input, manage the information flow (form and means of information acquisition, level of detail, accuracy, update rates, event notification etc.) in accordance with the information needs in the ATM pool;

- perform information interpretation and integration (data fusion) to provide a common view of the situation;

- prevent unauthorised inputs to the ATM pool.

The Information Dissemination Process - The final stage of IM consists of satisfying stakeholder information needs and ensuring that relevant information is used by *all* appropriate stakeholders as *timely* input to their decision making. To this effect, (distributed) information dissemination processes will continuously — for each type of shareable information:

- maintain an overview of potential users/consumers of information;

- track and anticipate the information needs of the information consumers, including identification of new information needs;

- dynamically maintain the scope of information interest (subscription filter) of the information consumers;

- for each subscription, manage the information flow to the information consumer (form and means of information delivery, level of detail, accuracy, update rates, event notification etc.);

- prevent unauthorised access to the ATM pool.

PAGE LEFT INTENTIONALLY BLANK

Appendix 10 Systems' Viewpoint

1   Preamble

The layout of the document, intended to give different readers the opportunity to concentrate on their own areas of interest means that descriptions of the future ATM network and concepts occur in a number of different places. This Appendix is designed to bring together the material of some of the more important of these systems into one place and to further expand on their descriptions.

2   Systems

2.1   Surface Management Systems

User Requirements

Airports have particular congestion and safety-related needs in surface movement for aircraft commencing or finishing a flight and for all the other airport surface movements (aircraft positioning, ground vehicles etc.), in which the efficiency of the airport infrastructure is very important. Particular attention needs to be paid to ways to enable Tower and Runway controllers to perform their tasks efficiently, to enhance airport capacity and to further increase safety.

Tower and Runway controllers interests however, extend beyond the airport boundaries and information is also required on and for traffic in intermediate and final approaches as well as on take-off and departure, such as wake vortex and wind shear conditions.

Surface Management Systems (SMS)s will provide data and assistance to all airport agencies operating aircraft or vehicles on the manoeuvring area (e.g. to ATC for aircraft departures and arrivals, to airlines for pre- or post-positioning of aircraft, to airport agencies for ground service and maintenance vehicles and to the emergency services). Using data on the planned and actual manoeuvres of all significant surface movements SMS will assist in their orchestration into an efficient and ordered interaction of movements aimed at reducing aircraft taxi times, fuel consumption and queuing, whilst maximising airport and runway throughput and so reducing the inefficiencies in aircraft and vehicle movements that can occur today.

The SMSs will provide controllers with real-time data on projected arrivals and departures, runway loading, airport congestion and gate assignments for active aircraft (those under ATC control),. Other airport agencies will be provided with a subset of the available data necessary for them to plan and carry out their movements whilst remaining clear of the active aircraft.

The SMS, linked to the airport AMS and DMS, and using passive and active detectors for movements on the airport surface and in its vicinity (such as sound and magnetic anomaly detectors, primary and secondary radar and ADS-B information) will provide an easily interpretable picture of forecast and actual movements on the airport and its approaches. This data will be used:

- firstly, by controllers, filtered for their specific use, to maintain a picture of all aircraft movements;

- secondly, by the ground service agencies units to organise their traffic, ensuring that ground vehicles and re-positioning aircraft remain clear of active flights;

- thirdly, by aircraft flight-crews sharing a subset of the data, transmitted by datalink.

SMS will have Conformance Monitoring capability so as to advise the controller controlling the flight, or the airport agency controlling its movements if a flight or vehicle is not conforming to its planned movements and to warn if the deviation carries the risk of causing a hazard to others.

2.2   Arrival and Departure Management

AMSs and DMSs at an airport will be linked to each other, to the airport SMS, to the en-route ATC system and to AMS/DMS at other airports so as to provide efficient and comprehensive exchange of relevant data. AMSs and DMSs will perform their functions in a number of different kinds of airspace and conditions in FFAS and MAS. To satisfy these different levels of demand there will be three main service levels. The systems will either:

- provide up-link data on airspace and timing restrictions to a flight to allow it to make a dynamic selection of its route or routing, which is then agreed between the flight and the ground;

- take a down-linked request for a route or routing from a flight, and by negotiation, either accept or impose minimal changes;

- impose the route or routing that the flight will be required to fly, which while optimised as much as possible to suit the performance wishes or capability of the flight, will have as its first priority the need regulate operations as safely and efficiently as possible.

2.3   En-Route Systems

The En-route systems in the pan-European ATM network will have to support operations with widely different levels of traffic; from high-density operations in the core area at peak periods, in which Structured Route flight in MAS is a necessity, through to Free Routing and Autonomous Aircraft operations. Of course, at certain times of day or night Autonomous Aircraft operations will be possible in the core area and peripheral areas will experience traffic peaks requiring structured routes.

It can be seen therefore that there will be a large degree of commonality among en-route systems, capable of supporting all modes of flight, from Structured Route flight, through Free-Routing to Autonomous Aircraft operations. In general, the systems will be able to:

- support dynamic restructuring of sectors, routes and boundaries;

- accept data on aircraft positions and intentions from a combination of ground surveillance and flight data sources;

- support RNAV-based and Satellite-data based navigation references as well as fixed ground facilities for 3-D and 4-D operations.